FINAL
TECHNICAL MEMORANDUM NO. 7

ADDENDUM TO FINAL PHASE II
RFI/RI WORK PLAN

Surface Soil Sampling and Analysis Plan

Rocky Flats Plant
903 Pad, Mound, and East Trenches

(Operable Unit No. 2)

U.S. DEPARTMENT OF ENERGY

Rocky Flats Plant
Golden, Colorado

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1.1 INTRODUCTION

The purpose of this Addendum to the Phase II Operable Unit No. 2 (OU-2) Alluvial RCRA Facility Investigation/Remedial Investigation (RFI/RI) Work Plan (EG&G 1991a) is to modify the Surficial Soil Sampling Program to include the analysis of all contaminants that are potentially present at OU-2 for use in the human health risk assessment. The OU-2 Surficial Soil Sampling Program contained in the Phase II RFI/RI Work Plan was designed to investigate the extent of plutonium, americium, and uranium contamination in surficial soils and to study the potential vertical migration of radionuclides through the soil column. Numerous soil studies were made at the Rocky Flats Plant (RFP) before the OU-2 Phases I and II RFI/RI investigations, some as early as 1971. These include soil scrapes and soil borings, as well as off-site studies and aerial and surface gamma surveys. Data from these studies were useful in developing the sampling plans for OU-2 Phases I and II. However, these data were not consistently validated and, in some cases, remain unpublished. The OU-2 Phase II Surficial Soil Sampling Program exceeds previous studies in completeness, validity, and geographic distribution. The Surficial Soil Sampling Program contained in the Phase II RFI/RI Work Plan is discussed further in Section 2.1.1 of this document.

Data from previous studies do not provide information on potential contaminants other than plutonium, americium, and uranium. In order to assess the potential human health risks associated with exposure to OU-2 soils, an evaluation of the nature and extent of non-radioactive contaminants, as well as other radioactive contaminants, is required. Additional data are necessary to evaluate potential human health risks from a variety of exposure pathways such as direct contact, incidental ingestion, and inhalation of dusts from surficial soils. The results of the health risk evaluation will be included in the RFI/RI report as part of the baseline human health risk assessment.

Secondary objectives for the surface soil sampling program are to provide additional supporting data for the environmental evaluation (EE) and allow assessment of remedial alternatives for cleanup of the contaminated soils in accordance with the National Contingency Plan (NCP). Risks will be presented in the OU-2 Baseline Human Health Risk Assessment, and remedial alternatives will be developed and evaluated in the Feasibility Study (FS). Remedial alternatives

will address remediation of all contaminated soils (surface and subsurface), groundwater, surface water, and sediments at OU-2 as necessary.

Section 1.0 of this sampling and analysis plan provides background information and data for OU-2 and a discussion of Data Quality Objectives (DQOs) for the Surface Soil Sampling Program. Section 2.0 presents the Sampling and Analysis Plan (SAP), and Section 3.0 discusses Quality Assurance/Quality Control (QA/QC) considerations. This work plan supplements the Phase II RFI/RI Work Plan for OU-2 (EG&G 1991a).

1.2 DQO PROCESS

The Data Quality Objectives (DQO) Process, as outlined in Data Quality Objectives for Remedial Activities (EPA 1987), is utilized in developing this work plan. The DQO process ensures that project objectives are defined, identifies the environmental data necessary to meet these objectives, and ensures that the data collected are sufficient and of adequate quality for the intended use.

The DQO process is an iterative process designed to focus on the decisions that must be made and to help ensure that site activities that acquire data are logical and cost effective. The DQO process has three stages. Although the three stages are discussed sequentially in this document, they are implemented in an interactive and iterative manner, whereby all DQO elements are continually reviewed and re-evaluated. As such, the DQO process is integrated with development of the SAP and may be revised as needed, based on the results of each data collection activity. DQOs are developed using the three-stage process described in the following sections as tailored to the surface soil sampling plan.

1.2.1 Stage 1 - Decision Types

Stage 1 (Identify Decision Types) defines the types of decisions that will be made regarding site remediation. These decisions are based on input from identified data users (Section 1.2.1.1) (i.e., risk assessors, remedial design engineers). In Stage 1, all available site information is compiled and analyzed (Section 1.2.1.2) in order to evaluate potential chemical fate and transport pathways at the site (Section 1.2.1.3). The information obtained in Stage 1 is used to identify decisions to be made and deficiencies (data gaps) in the existing information (Section 1.2.1.4). The outcome of Stage 1 is a definition of the objectives of the site investigation and an identification of data gaps.

Stage 2 (Identify Data Uses/Needs) involves specifying the data necessary to meet the objectives set in Stage 1. Stage 2 includes selecting the sampling approaches and the analytical options for the site, including evaluating multiple-option approaches to allow more timely or cost-effective data collection and evaluation.

In Stage 3 (Design Data Collection Program), the methods to be used to obtain data of acceptable quality are specified in products such as the SAP or the workplan.

1.2.1.1 Data Users

Physical and chemical data for the surface soils will be used for preparation of the OU-2 Baseline Human Health Risk Assessment and to provide additional supporting data for the environmental evaluation and feasibility study. The primary data users will be risk assessment scientists, statisticians, and feasibility study engineers. If additional detailed information is necessary for remedial design/remedial action, it will be collected as needed.

1.2.1.2 Current Understanding of Nature and Extent of Contamination

Site Location and Description

OU-2 is bounded on the north by South Walnut Creek, on the south by Woman Creek, on the east by Indiana Street, and extends to the western extent of the 903 Pad. OU-2 is divided into three areas: the 903 Pad, Mound, and East Trenches. These sites have been designated as having the potential to adversely impact the environment (DOE 1987). Twenty sites are designated as Individual Hazardous Substance Sites (IHSS) within OU-2. Five IHSS's are located in the 903 Pad Area, four IHSS's are located in the Mound Area, and the remaining 11 are located in the East Trenches Area. Figure 1-1 shows the IHSS locations within OU-2. Table 1-1 summarizes the disposal history for each IHSS as well as the suspected contaminant classes that may be present.

The majority of the IHSS's are disposal sites, which consisted of the shallow burial of waste in pits covered by fill. More specifically, 12 of the disposal sites (IHSS 108, 109, 110, 111.1, 111.2, 111.3, 111.4, 111.5, 111.6, 111.7, 111.8, and 113) were pits used for burial of hazardous and mixed wastes. IHSS's 153 and 154 were pits used for burning and burial of waste. IHSS 112 was used as a surface drum storage site for hazardous, low-level mixed, or mixed transuranic (TRU) wastes which leaked. IHSS 155 is contaminated with plutonium and americium from wind resuspension during clean-up efforts of the 903 Drum Storage site (IHSS 112). IHSS 140

Table 1-1
Operable Unit No. 2
Waste Disposal History

IHSS NO./NAME	AREA	DISPOSAL HISTORY	POTENTIAL SITE CONTAMINANT CLASSES	POTENTIAL FOR SURFACE SOIL CONTAMINATION
108/	Trench T-1 Site	Mound	125 drums of depleted uranium chips, plutonium chips, hydraulic oil and carbon tetrachloride disposed in the trench from 1954 to 1962.	VOCs; SVOCs; Radionuclides; Heavy Metals; Oil and Grease	Yes, two drums were inadequately covered with fill.
109/	Trench T-2 Site	903 Pad	Burial of sanitary sewage sludge and flattened drums containing uranium and plutonium; used prior to 1968.	VOCs; SVOCs; Radionuclides; Heavy Metals	None due to burial beneath fill
110/	Trench T-3 Site	East Trenches	Burial of sanitary sewage sludge contaminated with uranium and plutonium and flattened drums contaminated with uranium; used between 1954 and 1968.	VOCs; SVOCs; Radionuclides; Heavy Metals	None due to burial beneath fill.
111.1/	Trench T-4 Site	East Trenches	Burial of sanitary sewage sludge contaminated with uranium and plutonium, flattened drums contaminated with uranium, and uranium-contaminated asphalt planking from the solar ponds; used between 1954 and 1968.	VOCs; SVOCs; Radionuclides; Heavy Metals	None due to burial beneath fill.
111.2/	Trench T-5 Site	East Trenches	Burial of sanitary sewage sludge contaminated with uranium and plutonium and flattened drums contaminated with uranium; used between 1954 and 1968.	VOCs; SVOCs; Radionuclides; Heavy Metals	None due to burial beneath fill.
111.3/	Trench T-6 Site	East Trenches	Burial of sanitary sewage sludge contaminated with uranium and plutonium and flattened drums contaminated with uranium; used between 1954 and 1968.	VOCs; SVOCs; Radionuclides; Heavy Metals	None due to burial beneath fill.
111.4/	Trench T-7 Site	East Trenches	Burial of sanitary sewage sludge contaminated with uranium and plutonium and flattened drums contaminated with uranium; used between 1954 and 1968.	VOCs; SVOCs; Radionuclides; Heavy Metals	None due to burial beneath fill.

**Table 1-1
(Continued)**

IHSS NO./NAME	AREA	DISPOSAL HISTORY	POTENTIAL SITE CONTAMINANT CLASSES	POTENTIAL FOR SURFACE SOIL CONTAMINATION
111.5/	Trench T-8 Site	Burial of sanitary sewage sludge contaminated with uranium and plutonium and flattened drums contaminated with uranium; used between 1954 and 1968.	VOCs; SVOCs; Radionuclides; Heavy Metals	None due to burial beneath fill.
111.6/	Trench T-9 Site	Burial of sanitary sewage sludge contaminated with uranium and plutonium and flattened drums contaminated with uranium; used between 1954 and 1968.	VOCs; SVOCs; Radionuclides; Heavy Metals	None due to burial beneath fill.
111.7/	Trench T-10 Site	Burial of sanitary sewage sludge contaminated with uranium and plutonium and flattened drums contaminated with uranium; used between 1954 and 1968.	VOCs; SVOCs; Radionuclides; Heavy Metals	None due to burial beneath fill.
111.8/	Trench T-11 Site	Burial of sanitary sewage sludge contaminated with uranium and plutonium and flattened drums contaminated with uranium; used between 1954 and 1968. Also contained plutonium- and uranium-contaminated asphalt planking from the solar evaporation ponds.	VOCs; SVOCs; Radionuclides; Heavy Metals	None due to burial beneath fill.
112/	903 Drum Storage Site	Storage area for plutonium- and uranium- contaminated oil drums from 1958 and 1967. Liquids in the drums included mineral oil, carbon tetrachloride, hydraulic oil, vacuum pump oil, trichloroethylene, perchloroethylene, silicone oils, and acetone still bottoms. After 1959 ethanolamine was added to the drums. In 1968, an asphalt cap was placed on the pad after the removal of the upper 1-2 feet of soil. The soil was shipped offsite for disposal. The 903 Drum Storage Site is the historical source of contamination at IHSS 155.	VOCs; SVOCs; Radionuclides and Heavy Metals; Oil and Grease	None due to the removal of the upper soil and the placement of an asphalt cap, loose gravel and fill dirt over the spill areas. This area may be a potential source area if contaminants were transport-ed by dispersion prior to or during removal.

Table 1-1
(Continued)

IHSS NO./NAME	AREA	DISPOSAL HISTORY	POTENTIAL SITE CONTAMINANT CLASSES	POTENTIAL FOR SURFACE SOIL CONTAMINATION
113/ Mound Site	Mound	Drum disposal site used between 1954 and 1958 to store depleted uranium and beryllium contaminated hydraulic oil and carbon tetrachloride (no records indicate burial). Some drums were also contaminated with enriched uranium and plutonium and tetrachloroethylene. The site was cleaned up in 1970.	VOCs; SVOCs; Heavy Metals; Radionuclides	Yes, although there has been clean up of the site, previous surficial soil sampling has shown contamination and there are no records to indicate burial of the wastes.
140/ Reactive Metal Destruction Site	903 Pad	Destruction area for metallic Lithium in the 1950's to 1960's and again in 1968 through 1971. The metallic residues were buried. Other items destroyed include sodium, calcium, and magnesium metals; solvents; and unknown liquids.	VOCs; SVOCs; Pesticides/PCBs; Heavy Metals, Radionuclides	Yes, it is unknown if all destroyed items were buried. This site may be a potential source area if contaminants were transported by dispersion.
153/ Oil Burn Pit No. 2 Site	Mound	1,082 drums of oil containing uranium were burned in 1957 and 1961 to 1965. The drums used for oil burning were generally reused, but 300 drums were flattened and buried on the site. The residues from the burns and the flattened drums were covered with backfill. In 1978, the site was excavated to a depth of 5 feet and the contaminated soils were removed.	VOCs; SVOCs; Radionuclides, Heavy Metals	None due to soil removal. This area may be a potential source area if contaminants were transported by dispersion prior to or during removal.
154/ Pallet Burn Site	Mound	Wooden pallets were burned in 1965. Unknown hazardous substances and radionuclides may have been spilled on the pallets. The site was cleaned and reclaimed in the 1970's.	VOCs; SVOCs; Pesticides/PCBs; Radionuclides; Heavy Metals	None due to cleanup and reclamation.

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Table 1-1
(Concluded)

IHSS NO./NAME	AREA	DISPOSAL HISTORY	POTENTIAL SITE CONTAMINANT CLASSES	POTENTIAL FOR SURFACE SOIL CONTAMINATION
155/ 903 Lip Site	903 Pad	Plutonium was distributed by the wind from the 903 Pad to the Lip area during the Pad cleanup activities. Soils were hand excavated in 1976 until contamination was below the detection limit of the FIDLER. The area was covered with clean fill and reseeded. In 1978, soils were machine excavated until contamination was below the detection limit of the FIDLER. The area was covered with clean fill and reseeded. In 1984, more soil was removed from the area and the Lip site was backfilled with clean top soils.	VOCs; SVOCs; Radionuclides; Heavy Metals; Oil and Grease	Yes, soil sampling during Phase II indicated low levels of radionuclide contamination.
183/ Gas Detoxification Site	903 Pad	Compressed nitrogen oxides, chlorine, hydrogen sulfide, sulfur tetrafluoride, methane, hydrogen fluoride, and ammonia gases were detoxified using various chemical processes. After neutralization, gases were released to the environment and glassware used in the process was triple-rinsed, crushed and deposited in the present landfill.	VOCs; SVOCs; Pesticides/PCBs; Radionuclides; Heavy Metals	None; gases would no longer be present.
216.2/ East Spray Irrigation Site	East Trenches	Used for spray irrigation of sewage treatment plant effluent that contained low concentrations of chromium in February and March 1989.	Radionuclides; Heavy Metals	Yes, spray irrigation would deposit contaminants on the surface.
216.3/ East Spray Irrigation Site	East Trenches	Used for spray irrigation of sewage treatment plant effluent that contained low concentrations of chromium in February and March 1989.	Radionuclides; Heavy Metals	Yes, spray irrigation would deposit contaminants on the surface.

was used for destruction of reactive metals. IHSS 183 was used for detoxification of various types of gases. Spray irrigation of sewage plant effluents occurred at IHSS's 216.2 and 216.3.

Nature and Extent of Contamination

The current understanding of the nature and extent of contamination is based on the results of two previous sampling events, OU-2 Phase I and Phase II RFI/RI investigations. Numerous boreholes and groundwater monitoring wells were drilled and sampled during the OU-2 Phase I and Phase II investigations to characterize the nature and extent of contamination within the subsurface materials. Borehole composites from various intervals (surface to approximately 10 feet) were collected. The shallowest samples composited were from 0 to 2 feet.

Samples collected for the Surficial Soil Sampling Program contained in the OU-2 Phase II RFI/RI Work Plan were selected to evaluate the extent of plutonium, americium, and uranium contamination only, and therefore do not provide information on other potential contaminants within the surficial soils.

The Phase I and preliminary Phase II results indicate that the unconfined or upper hydrostratigraphic unit (UHSU) groundwater flow system is contaminated. The OU-2 UHSU includes the Rocky Flats Alluvium and the hydraulically connected Arapahoe Sandstone (No.1) groundwater flow system. The most pronounced organic contamination appears to be in the western portion of OU-2 as tetrachloroethane (PCE), trichloroethene (TCE), chloroform ($CHCl_3$), carbon tetrachloride (CCl_4), 1,2-dichloroethene (1,2-DCE), and 1,1,1-trichloroethane (1,1,1-TCA), ranging from parts per billion to parts per million. No organic contamination has been detected in the groundwater at the eastern portion of OU-2. Metals and inorganic concentrations exceeding background concentrations have been observed in the UHSU. These elements include strontium, barium, copper, and nickel, and to a lesser extent, chromium, manganese, selenium, lead, zinc, molybdenum, and total dissolved solids. Uranium[238] (U) is the predominant radionuclide detected (slightly above background levels) in the UHSU, but a few samples indicate the presence of plutonium and americium downgradient of the 903 Pad.

Soil sample analyses obtained from source borehole and plume characterization wells (Phase I and Phase II) (Figures 1-2A and 1-2B) indicate organic contamination (TCE, PCE, CCl_4, 1,1,1-TCA, 1,2-DCE, and $CHCl_3$) ranging from parts per billion to parts per thousand. Toluene has been detected in numerous soil samples across OU-2, and the source and significance has not been determined. In addition, methylene chloride and acetone have been detected; however, the blank samples also indicate the presence of those compounds, and therefore they could be

laboratory contaminants. Plutonium, americium, and uranium were detected above background in several source borehole samples. (See the RFP Sitewide Background Characterization report [EG&G 1990a] for background analyte concentrations.) Since both the Phase I and Phase II source borehole samples were composited from several depths, except VOC samples, the concentrations of radionuclides, metals, semivolatiles, total petroleum hydrocarbons, pesticides, and base neutral acid extractable (BNA) may not represent the near-surface soil contamination.

The locations of the Phase II OU-2 RFI/RI Work Plan surficial soil sampling grids are illustrated in Figure 1-3. Forty-four 10-acre grids and thirty-four 25-acre grids were sampled for americium^{241} (Am), plutonium^{239,240} (Pu) and uranium$^{233, 234, 235, and 238}$ (U) in OU-2 using the Colorado Department of Health (CDH) method (see Standard Operating Procedures [SOP] GT.8 Operating Procedures Volume III [EG&G 1992] for a description of the CDH method). All 78 grids were also resampled using the Rocky Flats (RF) method (also see SOP GT.8) and analyzed for Am^{241} and Pu^{239,240} and U$^{233, 234, 235 and 238}$. The initial surficial soil sampling results from the Phase II investigation show that above background upper tolerance limit levels of Am^{241} and Pu^{239,240} exist southeast (grids 21, 30, 36, 37, 48, 49, 56, 68, 80, and 95), east (grids 19, 20, 28, 29, 34, 35, 46, 47, 55, 79, and 88), and northeast (grids 26, 27, 32, 33, 44, 45, 53, 54, 61, 62, 66, 67, 72, 73, and 74) of the 903 Pad. The data support the hypothesis that the source of the plutonium and americium is wind dissemination during clean-up efforts at the 903 Drum Storage Site.

Geotechnical particle size analyses were performed on the very fine fraction soil obtained using the CDH method from each grid. The very fine fraction is defined as soil which passes through a 200 sieve (allows 74 micron particle to pass through). This very fine fraction can be used to estimate content of respirable (< 10 micron) and entrainable (50-100 micron) particles that may pose a risk via the air pathway.

The surface-water contamination in OU-2 is primarily confined to groundwater discharge points (seeps) in the 903 Pad and Mound Areas. The principal chlorinated hydrocarbons (CHC) that are detected in the 903 Pad Area seeps include 1,2-DCE, CCl_4, $CHCl_3$, PCE, and TCE with maximum concentrations reaching several hundred micrograms per liter (μg/L) in many samples. Elevated levels of plutonium have been detected in the surface-water samples from the seeps on the south and east side of the 903 Pad. These results could be due to wind resuspension and deposition and the subsequent mixing of sediments while sampling. Groundwater seeps in the Mound Area show some CHC contamination of 1,2-DCA, 1,2-DCE, 1,1,1-TCA, CCl_4, $CHCl_3$, PCE, and TCE as well as some vinyl chloride with maximum concentration reaching several hundred μg/L. Occasional low CHC contamination is detected

in the groundwater seeps along South Walnut Creek immediately north of the East Trenches Area of OU-2. Metals and other inorganic compounds occur intermittently above background in these groundwater seeps, the South Interceptor Ditch (SID), and Woman Creek (DOE 1992b). These metals and other inorganic compounds include total dissolved solids, major ions, strontium, and zinc.

Low concentrations of CHCs have been detected from sediment locations in South Walnut Creek, Woman Creek, and the SID ($CHCl_3$, CCl_4, TCE, and PCE in concentrations of less than 100 μg/L) (EG&G 1991b). Metals detected from sediment locations in the South Walnut Creek, Woman Creek, and the SID are beryllium, lithium, silver, and tin (EG&G 1991b). These metals were not detected in the background sediments sampled. Zinc, in concentrations above the background upper tolerance limit, were also detected in OU-2 sediments. Plutonium [239,240], U^{233}, Sr^{89}, Am^{241}, Cs^{137}, and tritium were detected above background from sediments in OU-2. Contaminated surface soil from the 903 Pad Area, transported by wind, may be the source of the plutonium.

Data Adequacy

The soil, sediment, and water quality data used for the preceding discussion were collected during the OU-2 Phase I and Phase II investigations and are either valid, acceptable with qualifications, or nonvalid pending complete validation (some analytical data for Phase II have not yet been received). Rejected samples were not used. Data validation is conducted in accordance with guidance provided in the Quality Assurance Project Plan (QAPjP) (EG&G 1990b) and General Radiochemistry and Routine Analytical Services Protocol (GRRASP) (EG&G 1990c).

With respect to representativeness, the previous results are from boreholes, monitoring wells, surface-water, and sediment stations whose locations were selected during the Phase I and Phase II planning to evaluate the nature and extent of contamination within the entire OU. However, surficial soil samples in OU-2 have only been analyzed for certain radionuclides, and therefore data are insufficient for other potential contaminants within the surficial soils to adequately determine exposure point concentrations necessary for the human health risk assessment.

1.2.1.3 Chemical Fate and Transport

To support data collection needs, an integral part of the DQO process is the evaluation of chemical fate and transport pathways. Surficial soil contamination at OU-2 has potentially resulted from waste spills and leaks, burning operations, and surface exposure of shallow buried waste as well as from the redistribution of contaminated dust via wind. Figure 1-1 shows the individual hazardous substance sites (IHSS's) contained within OU-2.

The chemical fate and transport flow diagram (Figure 1-4) portrays the potential release and transport mechanisms due to surficial soil contamination. The primary potential release mechanisms of contaminants from surface soils at OU-2 are stormwater runoff, volatilization, wind suspension, infiltration and percolation, direct contact, and exposure to external radiation. Human exposure to contaminants in surface soils can occur through each of these pathways; however, the actual pathways of significance will be determined during the risk assessment. The Draft OU-2 Exposure Scenario Technical Memorandum No. 5 (DOE 1992a) identifies the exposure scenarios that will be evaluated in the baseline human health risk assessment. The primary use of the surficial soil data obtained through this sampling and analysis plan will be to estimate exposure point concentrations for exposure pathways that will be evaluated in the baseline human health risk assessment.

1.2.1.4 Objectives/Approach

The Surficial Soil Sampling Program contained in the Phase II OU-2 RFI/RI Work Plan was designed to investigate the extent of plutonium, uranium, and americium contamination in surficial soils. In order to assess the potential human health risks associated with exposures to OU-2 surficial soils, an evaluation of the nature and extent of non-radioactive as well as other radioactive contaminants is required. Therefore, surficial soil samples will be collected to more fully characterize surface contamination in OU-2. The objective of this surface soil characterization plan is to provide physical and chemical soil data that are representative of the OU and can be used to:

- Characterize chemical concentrations in surface soil so that a representative mean and 95 percent upper confidence limit (UCL) on the arithmetic mean concentration can be developed at a prespecified level of confidence and accuracy (i.e., statistical sampling) (Section 2).

- Develop exposure point concentrations for exposure pathways that will be evaluated in the human health risk assessment.

- For purposes of the FS, delineate the area of contaminated surface soils that may require containment or treatment and/or disposal.

This surficial soil sampling plan has been designed so that samples are collected in a uniform manner and the results of the sample analysis are representative of the entire OU. In order to facilitate representative, uniform, random sampling, samples will be collected using approved Environmental Management Division (EMD) standard operating procedures (SOPs) (EG&G 1991b) as identified in Section 2.0.

The exposure scenarios presented in the Draft Exposure Scenarios Technical Memorandum No. 5 (DOE 1992a) identified three future on-site receptors: an industrial worker, an ecological researcher, and residents. The offsite and on-site exposure areas for current and future receptors that will be evaluated in the baseline human health risk assessment are shown in Figure 1-5.

Data from this surface soil sampling investigation will also be used to estimate exposure point concentrations off site using contaminant fate and transport modeling. Off-site concentrations of chemicals of concern will be used to evaluate potential risks to both current and future off-site residents.

1.2.2 Stage 2 - Data Uses/Needs

Stage 2 of the DQO process involves the identification of data uses and types as well as data quality and quantity needs to meet the objectives specified in Stage 1. It also includes the selection of the sampling approach and the analytical options for the task including the economic and technical feasibility of the technique chosen. Finally, DQOs must address the precision, accuracy, representativeness, comparability, and completeness (PARCC) parameters of the planned activities (EPA 1987).

1.2.2.1 Data Uses

To address the objectives outlined during Stage 1 of the DQO process, the anticipated uses for the collected data must be specifically stated. The data from the surficial soil sampling activities proposed herein will be used to characterize surficial soil contamination in OU-2. The

information will be used to evaluate potential public health risks and will also be used to evaluate remedial alternatives, if necessary. Specifically, the data collected will be used to support: (1) a fugitive dust model that can be used to calculate exposure point concentrations for the inhalation pathway and can also be used to estimate exposure levels due to plant ingestion offsite, (2) the 95% UCL concentration that will be used to develop exposure point concentrations for the on-site soil ingestion, plant ingestion and dermal absorption pathways, and (3) a contaminant runoff and transport model for estimating surface-water exposure point concentrations.

1.2.2.2 Data Types

Upon identification of the intended users and use of the data to be collected, the specific data types needed can be developed. Data types include general categories such as background and investigative samples as well as more specific information such as proposed analytical parameters. The analytical requirements are dictated by the intended use of the data (EPA 1987).

A Site-Specific Chemical Analyte Roster (S-SCAR) has been developed for OU-2. The criteria used to select the chemicals to be analyzed are presented in Table 1-2. Pertinent information reviewed as part of this selection process includes the following:

- Records of surface releases of analyte classes (i.e., radionuclides, semivolatiles, etc.).

- Chemicals previously detected in surface soils.

- Relative mobility (solubility, adsorption). Table 1-3 presents a summary of the intermedia migration characteristics of each of the organic analyte classes.

- Chemicals previously detected in subsurface soil borings or sediment samples.

As indicated in Table 1-1, several potential site contaminants are associated with the IHSS's in OU-2. Section 1.2.1.2 detailed the nature and extent of contamination at the site based on a review of available data. The previous discussions and data evaluation indicate that several contaminant classes should be analyzed during the surface soil sampling program. The contaminant classes that will be analyzed are outlined below.

TABLE 1-2

CONSIDERATIONS FOR IDENTIFYING THE SURFACE SOIL
SITE-SPECIFIC CHEMICAL ANALYSIS ROSTER (S-SCAR)

ANALYTE CLASS	SURFACE DISPOSAL	FOUND IN SURFACE SOILS	MOBILITY	FOUND IN BORING OR SEDIMENT SAMPLES	INCLUDE IN SURFACE S-SCAR
Radionuclides	Yes	Yes	Low to Moderate	Yes	Yes(1)
Metals	Yes	Not Sampled	Low to Moderate	Yes	Yes
Volatile Organics	Unknown	Not Sampled	Would Evaporate from Surface Soils	Yes	No(2)
Semi-Volatile (Base/Neutrals)	Unknown	Not Sampled	Generally Immobile	Yes	Yes
Semi-Volatile (Acid Extractables)	Unknown	Not Sampled	Generally Mobile	No	No(3)
Pesticides/PCBs	Unknown	Not Sampled	Immobile	Yes	Yes

(1)   As discussed in the text surface soil samples will be collected and analyzed for gross alpha, gross beta, $Ra^{226,228}$, Cs^{137}, and $Sr^{89,90}$ in the OU-2 area.

(2)   As discussed in the text, volatile organics will not be included in S-SCAR. It is expected that these compounds would have volatilized form surface soils and would no longer exist in detectable concentrations.

(3)   These compounds were not detected at OU-2. Considering the moderate to high soil mobility of this compound class, it is unlikely that acid extractable compounds deposited in the surface soils would remain in this disposition. Thus, this class has been excluded from the S-SCAR.

Table 1-3

Summary of Environmental Inter-Media Migration Characteristics

INTER-MEDIA MIGRATION CHARACTERISTIC	ALDEHYDES KETONES	MONOCYCLIC AROMATICS	CHLORINATED ALIPHATICS	ACID EXTRACTABLES	BASE-NEUTRAL EXTRACTABLES	PCB'S	PESTICIDES
Soil to Ground water	Yes	Yes	Yes	Yes	No	No	No
Soil or Soil Water to Air	No	Yes	Yes	No	No	No	No
Migration in Groundwater	Yes	Yes	Yes	Yes	No	No	No

Analyte Class I - Radionuclides

Radionuclides are included in the S-SCAR because records indicate historical surface releases and radionuclides have been detected in surface, soil boring, and sediment samples. The non-volatile nature of radionuclides coupled with their low to moderate solubility suggests they would persist in the environment near the ground surface. Therefore, surface soil samples collected during this proposed sampling effort will be analyzed for gross alpha, gross beta, $Sr^{89,90}$, Cs^{137}, and $Ra^{226,228}$. $Pu^{239,240}$, Am^{241}, and $U^{233,234,235,238}$ will not be analyzed for because sampling for these radionuclides was included in earlier OU-2 Phase II activities. Background sampling will be conducted as part of this OU-2 Surficial Soil Sampling Program and is discussed in detail later in this document. Tritium exists in the environment as tritiated water. If it were released to surface soils at OU-2, it would have been removed by infiltration and runoff due to its high mobility in the environment. Therefore, tritium is not on the S-SCAR because it is not expected to be found above background.

Analyte Class II - Metals

Metals are included in the S-SCAR because sewage treatment plant effluent containing low concentrations of chromium was inadvertently sprayed on the two East Spray Irrigation Sites (IHSS Nos. 216.2 and 216.3) in March 1989 and because of the potential for metals to be present at other IHSS's. Metals are generally relatively insoluble and are nonvolatile, suggesting persistence in the environment near the ground surface.

The analysis of hexavalent chromium was also included in this Surface Soil Sampling Program Addendum at 30 percent of the sampling locations because historical documentation indicated the potential presence of chromium in surface soils at OU-2 and because chromium (VI) is regarded by the EPA as a human carcinogen via inhalation (EPA 1992a). Analysis of chromium (VI) in soils requires extraction and analysis techniques that will preserve the valence states of the metals. In addition, chromium (VI) is highly reactive and will be reduced to chromium (III) when in contact with organic matter, which is a possibility for surface soils at the Rocky Flats Plant. Regardless, chromium (VI) has been included in the S-SCAR because of its toxicity.

Analyte Class III - Volatile Organics

Surface soils need not be analyzed for VOCs due to their high volatilization potential and high solubility. VOCs would have either volatilized into the air, solubilized in surface runoff water, or been transported to groundwater.

Analyte Class IV - Semi-Volatile Organics

Base/Neutral Extractables

There are no known releases of semi-volatile compounds, and previous surface soil samples were not analyzed for these compounds. However, base/neutral extractable, semi-volatile compounds are included in the S-SCAR because they have been detected in soil boring and sediment samples. In addition, they are relatively insoluble and display low volatility suggesting they would persist in the environment near the ground surface.

Acid Extractables

There are no detections of these chemicals in the soils/sediments at OU-2 reported detection limits. This class of compounds has low adsorption coefficient (K_{oc}) values ranging from 27 to 900 and high water solubility (WS) values ranging from 14 to over 82,000 ppm. These values are indicative of chemicals that do not adsorb to soil (K_{oc} < 1000) and are mobile in the environment (WS > 10 ppm) (Ney 1990). Table 1-3 is a summary of environmental inter-media migration characteristics. Accordingly, they are not included in the surface soil sampling S-SCAR.

Analyte Class V - Pesticides/PCBs

There are no documented surface releases of organochlorine pesticides or PCBs; however, previous surface soil samples were not analyzed for these compounds. Organochlorine pesticides and PCBs are included in the S-SCAR because they have been detected in borehole and sediment samples at the RFP and are a potential site contaminant class as determined from the disposal history (Table 1-1). In addition, they are relatively insoluble and non-volatile, suggesting persistence in the environment near the ground surface.

The S-SCAR and associated analytical methods and detection limits are presented in Table 1-4.

1.2.2.3 Data Quality

Analytical Level

Analytical methods and support levels must be evaluated during the development of site-specific DQOs. The parameters for which the analytical method is valid, its limitations, and any special

TABLE 1-4

SITE-SPECIFIC CHEMICAL ANALYSIS ROSTER (S-SCAR)

SUBSTANCE (Radionuclides)	REQUIRED DETECTION LIMIT (MDA)[a] SOIL MATRIX (pCi/g)
Gross Alpha	4.0
Gross Beta	10
$Sr^{89,90}$	1.0
Cs^{137}	0.1
Ra^{226}	0.5
Ra^{228}	0.5
Substance (Metals)	Nominal Detection Limit (mg/kg)[c]
Antimony	12
Arsenic	2.0
Barium	40
Beryllium	1.0
Cadmium	1.0
Calcium	2000
Cesium[b]	200
Chromium	2.0
Chromium VI[b]	1.0
Cobalt	1.0
Copper	5.0
Iron	20
Lead	1.0
Lithium[b]	20
Magnesium	2000
Manganese	3.0
Mercury	0.2
Molybdenum[b]	40
Nickel	8.0
Potassium	2000
Selenium	1.0
Silver	2.0
Sodium	2000
Strontium[b]	40
Thallium	2.0
Tin[b]	40

TABLE 1-4
(Continued)

Vanadium	10
Zinc	4.0
Substance (Semivolatiles)	Low Quantitation Limit (μg/kg)[c]
bis(2-Chloroethyl) ether	330
1,3-Dichlorobenzene	330
1,4-Dichlorobenzene	330
Benzyl alcohol	330
1,2-Dichlorobenzene	330
bis(2-Chloroisopropyl) ether	330
N-Nitroso-Di-N-propylamine	330
Hexachloroethane	330
Nitrobenzene	330
Isophorone	330
Benzoic acid	1600
bis(2-Chloroethoxy)methane	330
1,2,4-Trichlorobenzene	330
Naphthalene	330
4-Chloroaniline	330
Hexachlorobutadiene	330
2-Methylnaphthalene	330
Hexachlorocyclopentadiene	330
2-Chloronaphthalene	330
2-Nitroaniline	1600
Dimethyl phthalate	330
Acenaphthyalene	330
3-Nitroaniline	1600
Acenaphthene	330
Dibenzofuran	330
2,4-Dinitrotoluene	330
2,6-Dinitrotoluene	330
Diethylphthalate	330
4-Chlorophenyl phenyl ether	330
Fluorene	330
4-Nitroaniline	1600
4,6-Dinitro-2-methylphenol	1600

TABLE 1-4
(Continued)

N-Nitrosodiphenylamine	330
4-Bromophenyl phenyl ether	330
Hexachlorobenzene	330
Phenanthrene	330
Anthracene	330
Di-n-butylphthalate	330
Fluoranthene	330
Pyrene	330
Butyl benzyl phthalate	330
3,3-Dichlorobenzidine	330
Benzo(a)anthracene	330
bis(2-Ethylhexyl)phthalate	330
Chrysene	330
Di-n-octyl phthalate	330
Benzo(b)fluoranthene	330
Benzo(k)fluoranthene	330
Benzo(a)pyrene	330
Indeno (1,2,3-cd) pyrene	330
Dibenz (a,h) anthracene	330
Benzo (g,h,i) perylene	330
Substance (Pesticides/PCBs)	Detection Limit $(\mu g/kg)^c$
2-BHC	8.0
ß-BHC	8.0
8-BHC	8.0
8-BHC (Lindane)	8.0
Heptachlor	8.0
Aldrin	8.0
Heptachlor epoxide	8.0
Endosulfan I	8.0
Dieldrin	16.0
4-4'-DDE	16.0
Endrin	16.0
Endosulfan II	16.0
4,4'-DDD	16.0
Endosulfan Sulfate	16.0

TABLE 1-4
(Concluded)

4,4´ - DDT	80.0
2-Chlordane	80.0
8-Chlordane	80.0
Toxaphene	160
Arochlor-1016	80.0
Arochlor-1221	80.0
Arochlor-1232	80.0
Arochlor-1242	80.0
Arochlor-1248	80.0
Arochlor-1254	160.0
Arochlor-1260	160.0
	Method Detection Limit
Bulk Density Testing	

[a]   See Quality Assurance Project Plan (QAPjP) (EG&G 1990a) and General Radiochemistry and Routine Analytical Services Protocol (GRRASP) (EG&G 1990b). USEPA-CLP, Statement of Work for Organics, Multi-Media, Multi-Concentration, 10/86 (Rev. 1/87, 2/87, 7/87, 8/87, 2/88). USEPA-CLP, Statement of Work for Inorganics Analysis, Multi-Media, Multi-Concentration, 7/87.

[b]   Non-CLP Target Analytes - Required Detection Limit

[c]   Specific quantitation limits are highly matrix dependent. The quantitation limits shown are guidance and may not always be achievable.

mg/kg   milligrams per kilogram

mg/m^3 milligrams per cubic meter

pCi/g   picoCuries per gram

µg/kg   micrograms per kilogram

considerations that will affect data quality must be understood in order to select appropriate analytical methods for specific uses.

The analytical options available to support data collection activities are presented in five general levels (EPA 1987). These levels are distinguished by the types of technology and documentation used, and their degree of sophistication.

- LEVEL V - Nonstandard methods. Radiological analyses and analyses that may require method modification and/or development. These data can be used for risk assessment applications.

- LEVEL IV - Contract Laboratory Program (CLP) Routine Analytical Services (RAS). This level is characterized by rigorous QA/QC protocol and documentation and provides qualitative and quantitative analytical data. These data can be used for risk assessment application.

- LEVEL III - Laboratory analysis using methods other than CLP RAS. This level is used primarily to support engineering studies and risk assessments using standard EPA-approved procedures. Some procedures may be equivalent to CLP RAS without the CLP requirements for documentation.

- LEVEL II - This level is characterized by the use of portable analytical instruments which can be used on-site or in mobile laboratories stationed near a site. This level is appropriate for determining presence of contaminants, relative concentrations, and screening of samples.

- LEVEL I - This level is characterized by the use of portable instruments which can provide real-time data to assist in the optimization of sampling point locations.

Chemistry data derived from the proposed surface soil sampling and analysis program at OU-2 will be used to evaluate human health risks posed by contamination, if any. Analytical data need to be validated in order to be used for risk assessment. Only Level V and Level IV analytical reports provide sufficient documentation to allow for data validation. Although Level III analytical procedures are similar to Level IV, the documentation provided is not sufficient for data validation. Therefore, soil samples collected as part of this plan will be subjected to Level IV analytical procedures and reporting requirements. Radionuclides are considered non-

conventional analytes; therefore, the analytical level for these constituents is Level V (EPA 1990a).

<u>Detection Limits</u>

In this section, a comparison is made between analytical detection limits for the S-SCAR and the risk-based concentration of each analyte corresponding to EPA target risk levels. This risk-based concentration is referred to as an exposure limit (EL). ELs were developed to evaluate detection limits so that data collected will be sufficient for evaluation of the potential human health risks. ELs have been calculated for those analytes listed in the S-SCAR for OU-2 that are recognized as having chronic or carcinogenic health effects in humans (i.e., an Oral Reference Dose [RfD] or Carcinogenic Slope Factor [CSF] exists for the substance). RfDs and CSFs were taken from the Integrated Risk Information System (IRIS) (EPA 1992c) and/or Health Effects Assessment Summary Tables (HEAST) (EPA 1992a). ELs have been calculated using exposure scenarios for a residential receptor. ELs for a resident have been developed in this document because they are expected to give the lowest ELs for the OU-2 area. If the detection limits are acceptable for the residential ELs, then it was assumed that they would be acceptable for the other receptors also. These ELs have been calculated for comparison with the analytical method detection limits. Detection limits for analytes are specified in the GRRASP (EG&G 1990c).

A description of how these ELs were calculated is contained in Appendix A. Note that the ELs were developed using current knowledge and exposure assumptions regarding exposure scenarios at OU-2. These scenarios and their associated exposure assumptions may change when the baseline human health risk assessment is conducted based on site-specific information and professional judgment. The approach presented in Appendix A is meant only for the evaluation of detection limits and may not directly reflect assumptions to be used in the baseline human health risk assessment. The residential exposure scenario, for which ELs were developed, is expected to be the most limiting because the estimated intakes for this receptor will be higher than those for other receptors. Thus, if the ELs are acceptable for the residential receptor, they will also be acceptable for the other, lesser-exposed receptors.

Reference doses, carcinogenic slope factors, and relative potency factors used in the calculations are provided in Table A-4. Relative potency factors represent the relative carcinogenicity of the polycyclic aromatic hydrocarbons (PAHs) to benzo(a)pyrene. These relative potency factors are interim guidance issued by EPA Region IV (EPA 1992b).

Table A-5 compares ELs calculated for a future on-site residential receptor with analytical detection limits as specified in GRRASP. A review of this table reveals that, in general, GRRASP-specified detection limits are much lower than calculated ELs. Arsenic, beryllium, benzo(a)pyrene, and Aroclor 1254 were found to have ELs below the analytical detection limits. However, in all four cases, the estimated ELs were within a factor of 10 of the GRRASP-specified detection limits. These ELs were estimated using a target risk level of $1x10^{-6}$. Using the GRRASP-specified detection limits in place of the estimated ELs would result in a risk level of $5.5x10^{-6}$ for arsenic, $6.7x10^{-6}$ for beryllium, $3.0x10^{-6}$ for benzo(a)pyrene, and $1.9x10^{-6}$ for Aroclor 1254. In the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 CFR Part 300), EPA states that: "For known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper-bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6}." If GRRASP-specified detection limits are used, concentrations of arsenic, beryllium, benzo(a)pyrene, and Aroclor 1254 near the detection limits will result in estimated risk levels that are acceptable. Therefore, no special analytical procedures will be used.

Background Samples

Representative background analytical data are necessary for meaningful interpretations of surface soil data at OU-2. Background data determine naturally occurring spatial variability and concentration levels of a constituent. Background surface soil data can then be compared with data from OU-2 to determine the likelihood that concentrations of chemicals or elements, particularly those that are naturally occurring, represent waste activities at the OU. Background samples will be collected as part of the surficial soil sampling program at OU-2. A description of the background samples that will be collected is included in Section 2.2.3.

1.2.2.4 PARCC Parameters

The PARCC parameters are indicators of data quality. Precision is a quantitative measurement of the reproducibility of the data under a given set of conditions and may be determined by collecting field duplicate (replicate) samples. Accuracy measures the bias in a sampling program. Sampling accuracy can be assessed through the collection and analysis of field and trip blanks. Analytical accuracy is evaluated through the analysis of field and trip blanks and through the analysis of laboratory quality control (QC) samples and matrix spikes. The degree to which a data set is representative of the study area is known as representativeness. This criterion is best addressed by ensuring that the Sampling and Analysis Plan (SAP) justifies sampling locations and that a sufficient number of samples are collected. Completeness is

defined as the percentage of valid measurements; comparability is a qualitative indicator of how well newly collected data will be comparable with previously collected data. PARCC parameters for the surface soil sampling program are discussed in Section 3.0.

1.2.3 Stage 3 - Design Data Collection Program

Stage 3 results in the description of the procedures that will be implemented to obtain data of acceptable quality and quantity to make the required decisions. Through the process of addressing the elements identified in Stages 1 and 2, all the components required for completion of Stage 3 should be available. The SAP presented in Section 2.0 describes the data collection program for the surface soil sampling task. The plan discusses the protocols for sample collection including the types, locations, and frequency of samples to be collected. Section 3.0 presents QA/QC considerations.

2.1 PREVIOUS WORK

Surficial soil sampling programs at OU-2 have previously been limited to the investigation of radionuclide contamination. Several reports were prepared during the early seventies to evaluate plutonium levels in the surficial soil in and around RFP. The OU-2 Phase I study examined soils for other analytes including metals and volatile and semivolatile organic compounds (Rockwell International 1987). However, this study involved the compositing of samples from 0 to 2 feet or more. For risk assessment use, surficial soil samples from no deeper than the top 2 inches of soil are preferred, since soil from this zone is most likely to come into direct contact with humans or be subjected to wind erosion.

2.1.1 Phase I and II, 1987-1991

Several studies of RFP surficial soils have concluded that soils east of the 903 Pad are contaminated with plutonium and americium as a result of wind dispersal during cleanup operations (Krey and Hardy 1970; Seed et al 1971; Poet and Martell 1972; Johnson et al 1976; Little 1980; Little et al 1980). The most exhaustive study to date has been the Phase II RFI/RI currently underway. Surficial soil sampling for Phase II was performed during the summer of 1991, using the Colorado Department of Health (CDH) method (EG&G 1992). In addition to the surficial soil sampling performed by the CDH method, each grid was resampled using the RF method (EG&G 1992).

Under the CDH method, soil samples are collected by driving a stainless-steel sampling device (5.08 x 5.4 x 0.25 cm; 2 x 2-1/8 x 1/4 inch) into undisturbed soil. In the OU-2 program, 25 equally spaced subsamples collected by the CDH method were composited within a 10-acre area for Am^{241}, $Pu^{239,240}$ and $U^{233,234,235 \text{ and } 238}$ analysis. Due to large variations in soil-plutonium near the 903 Pad, 2.5-acre grids were used immediately east of the 903 Pad Area and were analyzed for Am^{241}, $Pu^{239,240}$, and $U^{233, 234, 235, \text{ and } 238}$. The CDH method was used so the soils could be evaluated according to State of Colorado guidelines, which require special construction techniques on lands with plutonium concentrations greater than 0.9 pCi/g of dry soil.

Under the RF method (Figure 2-1), soil samples are collected by driving a 10 x 10 cm (4 x 4 in) cutting tool 5 cm (2 in) into undisturbed soil. The sample within the tool cavity is collected and placed in a new 5-gallon stainless-steel can. In the OU-2 program, ten subsamples were collected from the corners and the center of two 1-meter squares, spaced 1 meter apart (Figure 2-2). Each set of 10 subsamples was composited into one sample resulting in a sample volume of 25,000 cm^3.

In this addendum, the RF method (Figure 2-1) is proposed to be used with a different sampling scheme (Figure 2-3).

2.2 PROPOSED WORK

2.2.1 Sampling Objective

The objective of this sampling plan is to collect data representative of nonradioactive and radioactive contamination in surface soil at OU-2 that can be used to estimate mean and 95 percent UCL contaminant concentrations. Potential human health risks for each contaminant can then be evaluated. Representative systematic sampling will be conducted to fulfill this objective. The samples will be equally spaced surface soil composites taken from polygons that entirely cover the area of interest and selected (biased) polygons that focus on known or suspected surface soil contamination. This approach provides for site-wide coverage and conservatively includes potential hot spots. In order to design the sampling program, the following must be defined:

    (1)   Objective of the sampling and analysis plan
    (2)   Area of interest
    (3)   The size of the polygon
    (4)   The compositing methodology for sampling a polygon
    (5)   The number of polygons to be sampled
    (6)   The locations of the polygons to be sampled

The principal objective of the sampling plan is to estimate contaminant concentration parameters such as the mean, variance, and confidence intervals so that source term estimates for fate and transport modeling and exposure point concentrations can be calculated. This objective is primarily to support the human health risk assessment where exposure scenarios such as incidental soil ingestion, inhalation of resuspended particulates, and dermal absorption of chemicals in soil may be evaluated.

PLAN VIEW OF ROCKY FLATS METHOD TEMPLATE:
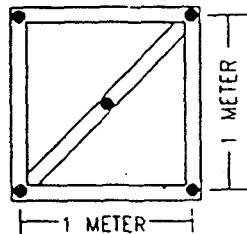
WOOD TEMPLATE WITH HOLES DRILLED IN EACH CORNER AND THE CENTER. NAILS WERE PLACED IN THE HOLES TO MARK THE SUBSAMPLE LOCATIONS. THE TEMPLATE WAS REMOVED AND THE SAMPLE JIG WAS USED TO COLLECT SAMPLES AT EACH SUBSAMPLE LOCATION.

SIDE VIEW OF ROCKY FLATS JIG:
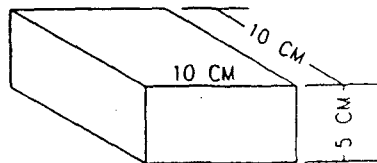
×   CENTER OF 10-ACRE POLYGON

●   SUBSAMPLE LOCATIONS

R33169.MBCW-020692

1 METER

1 METER | 1 METER | 1 METER

10-ACRE POLYGON

NOT TO SCALE

R33169 MBCW-020692

U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNITS NO. 1 AND 2
SURFACE SOIL SAMPLING AND ANALYSIS PLAN

10-ACRE SAMPLING SCHEME

FIGURE 2-2

January 1993

100'

50'

NOT TO SCALE

PLAN VIEW OF ROCKY FLATS METHOD TEMPLATE:

1 METER

1 METER

SIDE VIEW OF ROCKY FLATS JIG:

10 CM

10 CM

5 CM

• ROCKY FLATS METHOD
  SUBSAMPLE LOCATIONS
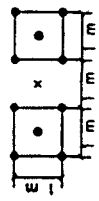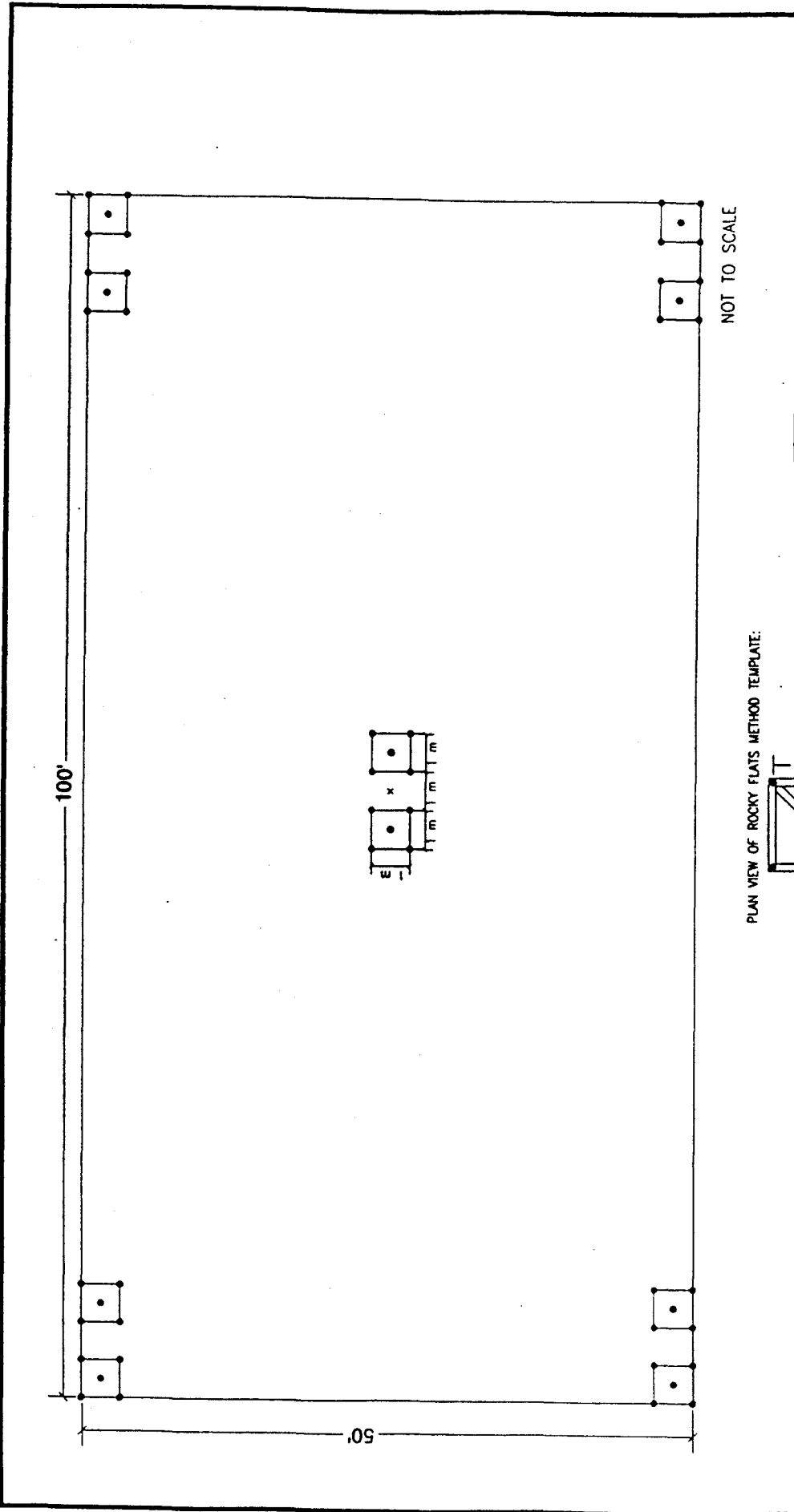
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNITS NO. 1 AND 2
SURFACE SOIL SAMPLING AND ANALYSIS PLAN

PROPOSED SAMPLING SCHEME
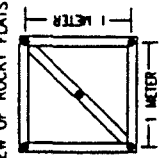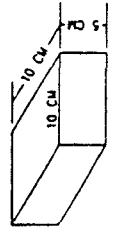
FIGURE 2-3

January 1993

R33170.MBCW-020692

2-5

2.2.2 Sampling Method

The size of the polygons to be sampled was selected based on the receptors to be evaluated in the risk assessment. The human receptors to be evaluated include: (1) an industrial worker, (2) an ecological researcher, and (3) a resident (Figure 1-5). The future on-site residential scenario will likely have the greatest potential exposure of the three receptors. Therefore, a sampling polygon representing an exposure area for an on-site resident will be utilized. The appropriate polygon size for the residential exposure area is 50 feet by 100 feet (EPA 1989).

The RF method described in SOP GT.8 Operating Procedures Manual, Volume III (EG&G 1992) will be used in conjunction with the sampling scheme shown in Figure 2-3. Fifty subsamples will be composited in each polygon.

The OU-2 area was divided into these polygons, and the polygons were numbered sequentially. Forty polygons were systematically selected for sampling as described below. A sample population of 40 will allow an adequate number of samples to assess contaminant distributions across OU-2. One composite soil sample will be taken from each polygon selected for sampling. If a sample polygon was determined to be located within a disturbed area (road, french drain, etc.), the sample location was eliminated and replaced by an adjacent, undisturbed polygon.

The information presented in Table 1-1 indicates that surface soil contamination is likely to be identified in several IHSS's. These IHSS's include 108 (Trench T-1), 113 (Mound Site), 140 (903 Pad Reactive Metals Disposal Site), 155 (903 Lip Site), and 216.2/216.3 (Spray Fields). To provide for sampling and analysis of surface soils in these IHSS's, 6 plots corresponding to these IHSS's were specifically selected for sampling. The remaining 34 samples were evenly-spaced throughout the OU-2 area.

This biased sampling approach was taken intentionally to provide for a more thorough characterization of surface soils in this area and to provide chemical concentrations and corresponding risks that would not underestimate actual risks in this area. Thus, the above sampling scheme will satisfy the requirements of the risk assessment and Feasibility Study by allowing for the estimation of surface soil chemical concentrations that are marginally biased toward detecting chemicals in surface soil, which is a more conservative approach for characterizing surface contamination at this OU. IHSS's with suspected surface soil contamination and the plots selected for surface soil sampling in this area are presented in Figure 2-4. Plots that were selected for biased sampling include 376, 405, 407, 508, 1637, and 1843.

The remaining 34 polygons selected were evenly-spaced, based on a grid, throughout the entire OU-2 area. The grid was developed by dividing the approximate area of OU-2 by 34 and then taking the square root. A grid with the resulting dimension was placed over the OU-2 area and the polygon in the center of the grid was selected. Figure 2-5 illustrates the polygons selected for sampling. This sampling scheme provides for a systematic and conservative characterization of potential surface soil contamination at OU-2 because it includes samples that are representative of the entire site as well as samples that are selected for potential surface soil contamination.

The southwest corner of each sampled polygon will be surveyed and identified with a marked stake or steel post, if not previously surveyed during the Phase II sampling program. The subsample location will be located using a hand-held compass and tape measure.

2.2.3 Background Surficial Soil Sampling

The analytical results from the OU-2 surficial soil samples collected will be compared with background concentrations. This comparison will be performed during the selection of Contaminants of Concern (COCs).

The OU-1 Surface Soil Sampling and Analysis Plan (DOE 1992b) included a discussion of the number of background samples required in order to obtain a 95 percent tolerance interval with a tolerance factor of 3 at the 95 percent confidence level (i.e., the number of samples required to produce an upper limit of the tolerance interval at the mean plus three standard deviations of the sample population). The analysis of the number of background samples in the OU-1 surficial soil sampling program is also applicable to OU-2, and nine sampling stations will also be collected in the background area for OU-2. Though the background samples collected under the OU-1 sampling plan are applicable for use in the OU-2 assessment, not all the OU-2 analytes of potential concern were analyzed (e.g., Cs^{137}, lithium). Therefore an additional nine randomly selected background grids will be sampled and analyzed.

The Rock Creek Drainage vicinity was chosen as the background area due to its location, geomorphology, and proximity to OU-1 background area. The background area is located generally northwest of the RFP processing area. Since the prevailing wind direction is from the northwest, it is presumed that the contaminants from operations at RFP would have had a nominal or minimal impact on the background area. The general geomorphology of the background area is similar to OU-2 with a pediment mesa composed of the Rocky Flats Alluvium between a south- and a north-facing slope covered with colluvial material. The OU-1

NOTICE

This document (or documents) is oversized for 16mm
microfilming, but is available in its entirety on
the 35mm fiche card referenced below:

Document # 000544

Titled: SURFICIAL SOIL SAMPLING

Technical memorandum

Fiche location: A-0402-M1

background area was included in the OU-2 background area for the following reasons: the south facing slope is similar to OU-2 and so that the OU-1 and OU-2 background analytical results could be combined.

The proposed background area was divided into 100-foot by 50-foot polygons and sequentially numbered. The nine polygons were selected for sampling with the use of a random number program. The proposed sampling locations as well as the OU-1 background sampling locations are shown in Figure 2-6. The RF sampling method (EG&G 1992) will be used for collecting samples in conjunction with the sampling scheme shown in Figure 2-3 for collecting the background samples.

2.3 ANALYSIS PLAN

The proposed analytical program for surficial soil sampling at OU-2 is presented in Table 2-1. As indicated, the list is sufficiently comprehensive to include expected contaminants based on the disposal history of OU-2. However, VOCs and acid extractables are not included because of the unlikelihood that these compounds would be present in the surface soil in OU-2. In order to provide a full suite of background analyte concentrations, several analyses have been added to the proposed analyte for background samples only and are shown in Table 2-2.

2.3.1 Radiochemistry

$Pu^{239,240}$, Am^{241}, and $U^{233,234,235, and 238}$ analyses will not be performed in this sampling effort, since substantial data have been obtained from previous studies. To provide additional information on radionuclide surface soil contamination, analyses to be performed are listed in Table 2-1 and consist of gross alpha and gross beta, $Ra^{226,228}$, $Sr^{89,90}$, and Cs^{137}. Radionuclide analyses will be performed in accordance with methods referenced in the GRRASP. $Pu^{239,240}$, Am^{241}, and $U^{233,234, and 238}$ will be evaluated in the background program as indicated in Table 2-2.

2.3.2 Non-Radiochemistry Analytical Parameters

CLP Target Compound List (TCL) for organic (semivolatile and Pesticide/PCBs) analyses and CLP Target Analyte List (TAL) for metals analyses will be performed as specified in the GRRASP. The non-CLP Target Analyte metals, cesium, chromium VI, lithium, molybdenum, strontium, and tin will also be performed in accordance with the GRRASP. The non-radiological analytical parameters and proposed reporting limits are also presented. Because chromium is a potential site-related chemical of concern in surface soil, hexavalent chromium

TABLE 2-1

PROPOSED OU-2 SURFACE SOIL SAMPLING PARAMETERS

TOTAL METALS

Antimony
Arsenic
Barium
Beryllium
Cadmium
Calcium
Cesium
Chromium
Chromium (VI)[a]
Cobalt
Copper
Iron
Lead
Lithium
Magnesium
Manganese
Mercury
Molybdenum
Nickel
Potassium
Selenium
Silver
Sodium
Strontium
Thallium
Tin
Vanadium
Zinc

OTHER PARAMETERS

Bulk Density Testing[b]
Specific conductance[a]
pH[a]
Carbonate[a]
Total Organic Carbon[a]

TOTAL RADIONUCLIDES

Gross Alpha
Gross Beta
Radium$^{226, 228}$
Strontium $^{89/90}$
Cesium^{137}

**ORGANICS:
SEMIVOLATILES
BASE/NEUTRAL
EXTRACTABLES**

Target Compound List -
    Phenol

bis(2-Chloroethyl)ether
2-Chlorophenol
1,3-Dichlorobenzene
1,4-Dichlorobenzene
Benzyl alcohol
1,2-Dichlorobenzene
2-Methylphenol
bis(2-Chloroisopropyl)ether
4-Methylphenol
N-Nitroso-Dipropylamine
Hexachloroethane
Nitrobenzene
Isophorone
2-Nitrophenol
2,4-Dimethylphenol
Benzoic acid
bis(2-Chloroethoxy) methane
2,4-Dichlorophenol
1,2,4-Trichlorobenzene
Naphthalene
4-Chloroaniline
Hexachlorobutadiene
4-Chloro-3-methylphenol
2-Methylnaphthalene
Hexachlorocyclopentadiene
2,4,6-Trichlorophenol
2,4,5-Trichlorophenol
2-Chloronaphthalene
2-Nitroaniline
Dimethylphthalate
Acenaphthylene
3-Nitroaniline
Acenaphthene
2,4-Dinitrophenol
4-Nitrophenol
Dibenzofuran
2,4-Dinitrotoluene
2,6-Dinitrotoluene
Diethylphthalate
4-Chlorophenyl phenyl ether
Fluorene
4-Nitroaniline
4,6-Dinitro-2-methylphenol
N-Nitrosodiphenylamine
4-Bromophenyl Phenyl ether
Hexachlorobenzene
Pentachlorophenol
Pentachlorophenol
Phenanthrene
Anthracene
Di-n-butylphthalate

**ORGANICS: SEMIVOLATILES BASE/NEUTRAL
EXTRACTABLES (continued)**

Fluoranthene
Pyrene
Butyl benzylphthalate
3,3'-Dichlorobenzidine
Benzo(a)anthracene
bis(2-ethylhexyl)phthalate
Chrysene
Di-n-octyl Phthalate
Benzo(b)fluoranthene
Benzo(k)fluoranthene
Benzo(a)pyrene
Indeno(1,2,3-cd)pyrene
Dibenz(a,h)anthracene
Benzo(g,h,i)perylene

ORGANICS: PESTICIDES/PCBs

Target Compound List -
    alpha-BHC
    beta-BHC
    delta-BHC
    gamma-BHC (Lindane)
    Heptachlor
    Aldrin
    Heptachlor epoxide
    Endosulfan I
    Dieldrin
    4,4'-DDE
    Endrin
    Endosulfan II
    4,4'-DDD
    Endosulfan sulfate
    4,4'-DDT
    Endrin ketone
    Methoxychlor
    alpha-Chlordane
    gamma-Chlordane
    Toxaphene
    AROCLOR-1016
    AROCLOR-1221
    AROCLOR-1232
    AROCLOR-1242
    AROCLOR-1248
    AROCLOR-1254
    AROCLOR-1260

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[a]   On 30 percent of the surface soil samples
[b]   On 20 percent of the surface soil samples

TABLE 2-2

ADDITIONAL PROPOSED OU-2 BACKGROUND
SURFACE SOIL SAMPLING PARAMETERS

TOTAL RADIONUCLIDES

Uranium[233,234,235 and 238]
Plutonium[239,240]
Americium[241]

(CrVI) analyses will be performed in 30 percent of the surface soil samples, including the 2 polygons to be sampled at the spray fields (IHSS's 216.2 and 216.3). Additionally, specific conductance, pH, and total organic carbon (TOC) analyses will be performed on 30 percent of the OU-2 and background samples.

Two of the OU-2 polygons to be sampled for the chromium VI, specific conductance, carbonate, pH, and TOC analyses were biased to include the spray fields. The corresponding polygon numbers are 1637 and 1843. The remaining ten OU-2 polygons to be sampled for these analyses were randomly selected and include 563, 1168, 1191, 1815, 4408, 4454, 6051, 6075, 6120, and 8227. For the background area, the polygons randomly selected for these analyses include 6, 7, and 8.

2.3.3 Physical Parameters

A subset of approximately 20 percent of the OU-2 and background samples will be collected and submitted for bulk density testing. As stated in Section 1.2.1.2, geotechnical particle size analyses were obtained in conjunction with the OU-2 Phase II CDH method sampling and therefore particle size analyses will not be required during this sampling activity. Particle size analysis will be used to evaluate the respirable fraction and entrainable fraction. These are for risk assessment and modeling, respectively. The bulk density analysis will enable the concentration units to be converted to concentration per unit area. The suggested 20 percent frequency for collection of these samples will provide sufficient information to characterize the soils. The OU-2 polygon locations for the bulk density testing were randomly selected and include 2893, 2916, 2940, 4361, 4454, 4478, 6191, and 8157. The background locations randomly selected for bulk density testing include polygons 5 and 7.

2.4 DATA MANAGEMENT

Field and laboratory data collection during the Phase II RFI/RI will be incorporated into the Rocky Flats Environmental Database System (RFEDS). The RFEDS is used to track, store, and retrieve project data. Data will be input to the RFEDS via diskettes subsequent to data validation as outlined in the ER Program QAPjP (EG&G 1990b). Hardcopy reports will then be generated from the system for data interpretation and evaluation.

The SAP addresses the procedures for conducting the proposed field activities as well as the proposed analytical suite for the samples collected during the OU-2 surface soil sampling program. A QAPjP is an element of the SAP that identifies QA objectives for data collection, analytical procedures, calibration, and data reduction, validation, and reporting. The QAPjP, in conjunction with SOPs, completes the SAP. The ER Program QAPjP and the Rocky Flats EMD SOPs have been prepared by EG&G and submitted to the EPA and the CDH for review and comment. All field and analytical procedures will be performed in accordance with the methods described in the QAPjP and SOPs unless otherwise specified in this SAP.

3.1 INTERNAL QC CONTROL SAMPLES

The objective of the QAPjP is to provide a framework to ensure that all sampling and analytical data achieve specific data quality standards. These standards ensure that PARCC parameters (Section 1.2.2.5) for the data are known and documented. All samples sent for CLP Level IV analyses will be handled in accordance with CLP guidelines. QC procedures for non-CLP methods will be developed as needed using standard methods.

QC samples may be collected in conjunction with the investigative samples to provide information on data quality. Equipment rinsate blanks, trip blanks, field duplicates, laboratory blanks, laboratory replicates, and laboratory matrix spike and matrix spike duplicates are the commonly collected samples. Trip blanks generally pertain to volatile organic analyses; and because volatile organic analyses will not be performed on the samples collected during the surface soil sampling program, trip blanks will not be collected for this program.

Rinsate blanks will be collected by pouring distilled/deionized water through decontaminated sample collection equipment and submitting the sample for the same analyses as the investigative samples. Rinsate blanks monitor the effectiveness of decontamination procedures. Field duplicates will be collected and analyzed to provide information regarding the natural variability of the sampled media as well as to evaluate analytical precision. A split of the composite sample will be performed to obtain the field duplicate. Table 3-1 presents the suggested guidelines for collection of field QC samples (EPA 1987) which are consistent with the suggested guidelines listed in the QAPjP. Tables 3-2a and 3-2b present the total number of investigative samples to be collected for OU-2 and the background area during

TABLE 3-1

**GUIDELINES FOR FIELD QUALITY CONTROL
SAMPLE COLLECTION FREQUENCY**

Activity	Frequency
Field Duplicate	1 in 20
Field Blanks	NA[1]
Trip Blank	NA[2]
Equipment Rinsate Blank	1 in 20 or once per day, whichever is more frequent

[1]   The use of field blanks for soil sampling at the RFP is not appropriate because of the lack of commercially available blank soils that adequately reflect the various soil types encountered.

[2]   Trip blanks are used for volatile samples only and therefore are not applicable to the samples being collected for surface soils.

TABLE 3-2A

OU-2
SURFACE SOIL SAMPLE FREQUENCY

Analytical Parameter	Total Surface Soil Investigative Samples	Trip Blanks	Field Duplicates[a]	Rinsate Blanks[b]	Total Samples for Lab
Metals[c]	40	NA	2	12	54
Radionuclides	40	NA	2	12	54
TCL Semi-volatiles (base/neutral extractable)	40	NA	2	12	54
TCL Pesticide/ PCBs	40	NA	2	12	54
bulk density testings[d]	8	NA	NA	NA	8
Specific Conductance, Carbonate, pH, and Total Organic Carbon[e]	12	NA	NA	NA	12

[a] 5% for soil samples
[b] 5% for soil samples or once per day whichever is more frequent, estimate of 12 days to perform the field sampling
[c] 30% will be submitted for Chromium VI analysis
[d] 20% of surface soil samples will be submitted for analysis
[e] 30% of surface soil samples will be submitted for analysis

NA   Not applicable

TABLE 3-2B

BACKGROUND SAMPLE AREA
SURFACE SOIL SAMPLE FREQUENCY

Analytical Parameter	Total Surface Soil Investigative Samples	Trip Blanks	Field Duplicates[a]	Rinsate Blanks[b]	Total Samples for Lab
Metals[c]	9	NA	1	2	12
Radionuclides	9	NA	1	2	12
TCL Semi-volatiles (base/neutral extractable)	9	NA	1	2	12
TCL Pesticide/ PCBs	9	NA	1	2	12
Bulk density testings[d]	2	NA	NA	NA	2
Specific Conductance, Carbonate, pH, and Total Organic Carbon[e]	3	NA	NA	NA	3

[a]   5% for soil samples

[b]   5% for soil samples or once per day whichever is more frequent, estimate of 2 days to perform field sampling

[c]   30% will be submitted for Chromium VI analysis

[d]   20% of background surface soil samples will be submitted for analysis

[e]   30% of background surface soil samples will be submitted for analysis

NA   Not applicable

implementation of this SAP. The polygon locations selected for field duplicates for OU-2 include 563 and 8087, and the background area polygon selected for a field duplicate is 6.

Laboratory blanks and replicates test analytical procedures and conditions. Laboratory matrix spikes and matrix spike duplicates measure analytical accuracy by providing data on matrix interferences and components interfering with instrument responses. The frequency of collection and analysis of laboratory QC samples is dictated by the prescribed analytical method as cited in the GRRASP. Currently no EPA-approved extraction process for the quantitation of chromium VI in a solid matrix exists. The extraction process previously published in the 2nd edition of SW-846, method 3060, was not included with the 3rd edition. The laboratory approved by EG&G to perform chromium VI analysis has developed a standard operating procedure (SOP) for CrVI extraction based on this method.

In order to fully evaluate the extraction process and analysis used by the subcontracted laboratory, 100 percent of the samples collected for chromium analysis will be spiked by the laboratory. These data will be used to evaluate chromium VI recovery and verify that the laboratory has acceptable method control. The precision and accuracy standards detailed in the proposed analytical method are sufficient for the project.

Chromium VI samples have a holding time of 48 hours. Since there are radiological screening requirements that take a minimum of 24 hours to perform, the samples scheduled for chromium VI analysis will be submitted to the laboratory immediately upon notification of clearance. The samples should arrive within 48 hours of the sampling event.

3.2 ACCURACY

Analytical accuracy is expressed as the percent recovery of an analyte that has been used to fortify an investigative sample or a standard matrix (e.g., blank soil, analyte-free water, etc.) at a known concentration prior to analysis, and is expressed by the following formula:

$$\text{Accuracy} = \% \text{ Recovery} = \frac{A_T - A_O \times 100\%}{A_F}$$

Where: A_T = total amount found in fortified sample
  A_O = amount found in unfortified sample
  A_F = amount added to sample

The fortified concentration will be specified by laboratory quality control requirements, or may be determined relative to background concentrations observed in the unfortified sample. In the latter case, the fortified concentration should be two to five time the background concentration to permit a reliable recovery calculation.

The quality assurance objective for organic and inorganic analyses are tailored to the analytical technique used, and are discussed separately in subsequent sections.

3.2.1 Metals Analysis

For analysis of metals, analytical accuracy is obtained from the analyte recovery measured in a laboratory control standard and/or sample fortified (spiked) with the element of interest. For this project, ten percent of the environmental samples submitted for analysis will be spiked, and 100 percent of the chromium VI samples submitted for analyses will be spiked. The QA objectives for accuracy in routine metals analysis for these QC samples are summarized below:

Sample	Recovery (%)
Laboratory Control Standard (LCS)	80-120
Spike Field Sample	75-125

Recovery values outside the QC limits for a Laboratory Control Standard (LCS) for the metals to be analyzed in this project will trigger compensatory action. Recovery values for fortified field samples are advisatory only and do not require corrective action.

3.2.2 Organic Analysis (GC and GC/MS)

For organic analysis, analytical accuracy is obtained from the surrogate recovery measured in each sample and blank and/or from the analysis of samples or blanks which have been fortified with a select number of target analytes. For this project, ten percent of the samples submitted for analysis will be fortified.

The QA objectives for accuracy are summarized in Table 3-3 for GC/MS surrogates and in Table 3-4 for GC/MS fortified samples. The recovery values for surrogates and target analytes in investigative sample analyses are advisory for routine laboratory analysis, whereas only recovery values for standard matrix samples (e.g., blanks) are used for triggering corrective action.

TABLE 3-3

QUALITY ASSURANCE OBJECTIVES FOR ACCURACY
FOR ORGANIC SURROGATE ANALYSES

Fraction**	Surrogate Compound	% Recovery Limits* Low/Medium Soil/Sediment
BNA	Nitrobenzene-d5	23-120
BNA	2-Fluorobiphenyl	30-115
BNA	p-Terphenyl-d14	18-137
BNA	Phenol-d5	24-113
BNA	2-Fluorophenol	25-121
BNA	2,4,6-Tribromophenol	19-122

*   U.S. EPA (1986). SW-846, 3rd Edition. Methods 8240 and 8270.
**   BNA Semivolatile Base/Neutral Extractable.

TABLE 3-4

QUALITY ASSURANCE OBJECTIVES FOR ACCURACY AND PRECISION FOR ORGANIC TARGET COMPOUND ANALYSES

Fraction	Matrix Spike Compound	% Recovery Limits Soil/Sed	% RPD Limits Soil/Sed
BN	1,2,4-Trichlorobenzene	38-107	23
BN	Acenaphthene	31-137	19
BN	2-4-Dinitrotoluene	28-89	47
BN	Pyrene	35-142	36
BN	N-nitroso-di-N-propylamine	41-126	38
BN	1,4-Dichlorobenzene	28-104	27
PESTICIDE	Lindane	46-127	50
PESTICIDE	Heptachlor	35-130	31
PESTICIDE	Aldrin	34-132	43
PESTICIDE	Dieldrin	31-134	38
PESTICIDE	Endrin	42-139	45
PESTICIDE	4,4-DDT	23-134	50
PCB	Arochlor 1254		50*

% RPD - Relative Percent Difference

This list includes those compounds most commonly used for QA/QC accuracy and precision control in the groups of analytes shown based on current U.S. EPA CLP requirements. (USEPA SOW 2/88 as revised through 5/89.) Stated control limits will be updated to the current CLP protocol, as required.

*Laboratory Determined Limits

3.3 SENSITIVITY

The sensitivity for each analytical parameter using the assigned methodology is sufficient to meet the project requirements. The project specific sensitivity (quantitation limits) for each parameter are listed in the GRRASP or CLP method and are listed in Table 1-4.

3.4 QUALITY ASSURANCE OBJECTIVES FOR PRECISION

Analytical precision is calculated by expressing the difference between duplicate sample analytical results relative to the average of those results for a given analyte expressed as a percentage. Precision can be expressed by the formula:

$$\% \text{ RPD} = \frac{|C_1 - C_2| \times 100\%}{(C_1 + C_2)}/2$$

Where: RPD   =   Relative percent difference

            C_1 =   Concentration of analyte in sample

            C_2 =   Concentration of analyte in replicate

On the occasion when three or more replicate analyses are performed, precision is expressed as the standard deviation of the analytical results of the replicate determination relative to the average of those results for a given analyte as a percentage. This precision measurement, percent relative deviation (% RSD), will have QA objectives identical to those for % RPD, and can be expressed by the formula:

$$\% \text{RSD} = \frac{\Sigma \, [C^2 - ((C)^2/n))] \, (n-1) \times 100\%}{(C_1 + ...C_n/n}$$

where: RSD   =   percent relative deviation

        C   =   concentration of analyte in the sample, and $(C_1 + C_2 +...C_n)$ represents the sum of the concentration of each replicate

        n   =   number of replicate analyses

        Σ =   "the summation of"

The QA objectives for metals (and other inorganic parameters) analysis are different from those for organic analyses. These QA objectives are discussed separately in subsequent sections.

3.4.1 Metals Analyses

For the metals analyses, the QA objective for precision is $\pm$ 20% RPD for soils (EPA 1990a). Percent RPD values outside the QC limits for duplicate LCS analyses will trigger corrective action. Percent RPD for duplicate investigative sample analyses are advisory only. For this project, five percent of the investigative samples submitted for analysis will be analyzed in duplicate.

3.4.2 Organic Analyses (GC, GC/MS)

For organic analyses, precision is measured by comparison of the recovery of a select number of target analytes in duplicate fortified samples for duplicate fortified blanks (e.g., matrix spike/matrix spike duplicate (MS/MSD) and/or blank spike/blank spike duplicate (BS/BSD). For typical GC/MS or GC analysis, two sample containers are collected for each analysis. Ten percent of the samples are collected in triplicate: one for investigative sample analysis, one for matrix spike analysis, and one for a matrix spike duplicate analysis. The QA objectives for precision as expressed by the % RPD for duplicate analysis of target analytes are given in Table 3-3. These RPD limits for investigative samples provide an indication of sample homogeneity and representativeness.

The laboratory QA Officer will be responsible for insuring analytical results meet QC criteria described for the appropriate EPA analytical method and for implementing corrective actions and specified in the analytical methods. Corrective actions may include a laboratory audit to resolve problems and reanalysis of the samples or, if difficulties cannot be resolved, resampling and submittal to another laboratory.

3.5 REPRESENTATIVENESS

Representativeness expresses the degree to which sample data accurately and precisely represent a population characteristic, parameter variation at a sampling point, or an environmental condition. Care has been taken in the design of the sampling program (described in Section 2 of the SAP) to ensure that sample locations are selected properly, consistency in sample collection techniques is maintained, a sufficient number of samples are collected to accurately reflect conditions at the site, and samples are representative of the sampling locations. The statistical method used to derive the number of investigative samples to be collected (described in Section 2) will provide data which is representative of the study area.

3.6 DATA COMPARABILITY

Published standard sampling and analytical methods will be used for chemical analyses. Reports will contain final results (uncorrected for blanks and recoveries), methods of analysis, levels of detection, surrogate recovery data, and method blank data. In addition, special analytical problems, and/or any modifications of referenced methods will be noted. The number of significant figures reported will be consistent with the limits of uncertainty inherent in the analytical methods. Consequently, most analytical results will be reported to no more than two significant figures. Data are normally reported in units commonly used for the analyses performed. Concentrations in liquids are expressed in terms of weight per unit volume (e.g., milligrams per liter). Concentrations in solid or semi-solid matrices are expressed in terms of weight per unit weight of sample (e.g., micrograms per gram). Reported detection limits will be the concentration in the original matrix corresponding to the low level instrument calibration standard after concentration, dilution, and/or extraction factors are accounted for, unless otherwise specified by program requirements. Through the use of the Rocky Flats method, the data collected during implementation of this SAP will be comparable with previously collected data. In addition, analyses of previously obtained samples were performed through the use of CLP-RAS and, therefore, will be comparable to the data resulting from the analyses of the samples collected during this program.

3.7 COMPLETENESS

Completeness is a measure of the amount of valid data compared to the amount of planned data for a specific set of measurements. It is expressed as a percentage. Historical completeness for CLP-RAS is 80 to 85 percent. For sampling completeness, a goal of 90 percent has been set for this program.

3.8 SAMPLE MANAGEMENT

Field preparation requires organizing sample containers and sample labels, and documenting in an orderly, systematic manner that promotes consistency and traceability of data. Table 3-5 lists the appropriate sample containers, volume, preservative, and holding time for each proposed analytical suite/parameter. The precleaned sample containers will be furnished by the EG&G selected contract laboratory conducting the analysis.

TABLE 3-5
SAMPLE CONTAINERS, SAMPLE PRESERVATION, AND SAMPLE HOLDING TIMES

SOIL MATRIX

Parameter	Container	Preservative	Holding Time
Soil, Sediment or Sludge Samples - Low to Medium Concentrations			
Organic Compounds:			
Extractable Organics (BNAs), Pesticides and PCBs	1 x 8-oz wide-mouth glass jar	Cool, 4°C	7 days until extraction, 40 days after extraction
Organophosphorous Pesticides and herbicides	1 x 8-oz wide-mouth[b] glass jar	Cool, 4°C	7 days until extraction, 40 days after extraction
Dioxins/Furans	1 x 8-oz wide-mouth glass jar	Cool, 4°C	7 days until extraction, 40 days after extraction
Inorganic Compounds:			
Metals (TAL)	1 x 8-oz wide-mouth glass jar	None	6 mo[1]
Toxicity Characteristic Leaching Procedure (TCLP)	8-oz wide-mouth glass with Teflon®-lined lid closure	None	Extract 7 days, Analyze within 40 days
Nutrients, including: Nitrogen, Phosphorus, Chemical Oxygen Demand	8-oz wide-mouth glass with Teflon®-lined closure	None	ASAP
Other Inorganic Compounds	8-oz wide-mouth glass with Teflon®-lined closure	None	ASAP
Radiological tests[2] and Tritium	1-liter glass[3]	None	None

Abbreviations: ASAP - as soon as possible

1   Holding time for mercury is 28 days.
2   For Radiological Testing, the specific analyses will be defined as some or all of the following: Gross Alpha, Gross Beta, Uranium 233+234, 235, and 239, Americium 241, Plutonium 239+240, Tritium, Strontium 90,89, Cesium 127, Radium 226, 228.
3   Full suite.

Each collected sample will be properly labeled, sealed, and placed in an appropriate container for transport to the laboratory. Chain-of-custody seals, which serve as tamper detection devices, will be placed around the top of each sample container and shipping vessel. All collected samples will be logged onto an appropriate chain-of-custody form. Custody transfers made will be documented on the form with the signature of the relinquishing and receiving parties followed by the date of the transfer. All appropriate chain-of-custody protocols will be implemented throughout the collection, shipping, and analysis activities.

3.9 DATA REPORTING

The chain-of-custody documentation will be included in the data package received from the analytical laboratory. The analytical data will be submitted to EG&G via electronic diskette for input into the RFEDS data tracking system.

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The following appendix provides documentation for the calculation of risk-based exposure limits (ELs) for analytes to be evaluated in this Surface Soil Sampling Program. The risk-based ELs developed in this section are compared to analyte detection limits to evaluate the need for special analytical services. If an EL for a given chemical is lower than the corresponding detection limit for that chemical, then the analytical method may not be sufficiently sensitive for evaluating potential risks for that chemical and alternative analytical methods for that chemical are needed. The ELs presented below were developed based on EPA risk assessment guidance (EPA 1991a), site-specific data, and professional judgment. The intake assumptions used in this appendix are solely for the purpose of evaluating chemical detection limits. The intake and other assumptions to be used in the baseline human health risk assessment (BHHRA) for the OU-2 will be developed and approved as part of the Exposure Assessment Technical Memorandum, which is part of the BHHRA. The ELs presented below were developed for a residential receptor and are expected to be conservative due to the exposure frequency and duration assumptions for this receptor.

Exposure Limits have been compiled based on non-carcinogenic (systemic) and/or carcinogenic properties of the contaminants. A more detailed summary of these methods is provided in EPA risk assessment guidance documents (EPA 1989, 1991a). The potential for non-carcinogenic health effects are quantified by comparing the daily intake (DI) to a reference dose (RfD) as shown below.

$$\text{Non-cancer Hazard Quotient (HQ)} = \text{DI/RfD} \tag{1}$$
$$\text{Where:} \quad \text{DI} = \text{daily intake (mg/kg-day)}$$
$$\text{RfD} = \text{reference dose (mg/kg-day)}$$

Non-carcinogenic risks from multiple contaminants are conservatively assumed to be additive. A noncancer hazard index (HI) is computed by summing HQs for each contaminant.

$$\text{HI} = \text{DI}_1/\text{RfD}_1 + \text{DI}_2/\text{RfD}_2 + \cdots\text{DI, RfD} \tag{2}$$

A HI less than 1 implies there will not be systemic health effects from exposure to the contaminants. Therefore, for each contaminant, the HQ has been set at 1.0.

Calculated carcinogenic risks estimate the increased likelihood of an individual contracting cancer during his/her lifetime due to contaminant exposure. Carcinogenic risks from multiple contaminants are also assumed to be additive.

Where:
Risk	=	CDI x CSF	(3)
CDI	=	Chronic Daily Intake (mg/kg-day) or (pCi)	
CSF	=	Carcinogenic Slope Factor (mg/kg-day)$^{-1}$ or (pCi)$^{-1}$	

For each contaminant, the risk has been set at 10^{-6} in computation of the EL to allow for the additive effects of the other contaminants and exposure pathways. This is expected to result in the cumulative risk from site carcinogens in the range of 10^{-4} to 10^{-6}, which is the target risk range for remediation of a site (EPA 1989).

The following equation is used to estimate the intake (CDI or DI) resulting from non-radioactive contaminant ingestion.

$$\text{Intake (mass contaminant/body mass/time)} = \frac{EL \times IR \times ED \times EF \times FI \times ME \times CF}{BW \times AT} \quad (4)$$

Where:

EL	=	Concentration in soil, at the point of exposure (EL) (mass contaminant/mass soil)
IR	=	Ingestion Rate (mass soil/time)
BW	=	Body Weight (mass)
ED	=	Exposure Duration (time)
AT	=	Averaging Time (time)
EF	=	Exposure frequency (unitless)
FI	=	Fraction ingested from contaminated source

	ME	=	Matrix Effect is the reduced availability due to adsorption of chemicals to soil compared to same dose administered in solution
	CF	=	Conversion factor (kg/mg)

The following equation is used to estimate the intake (CDI or DI) resulting from radionuclide soil containment ingestion.

$$\text{Intake (Activity)} \qquad EL \times IR \times ED \times EF \times FI \times ME \times CF \qquad (5)$$

Where:	EL	=	Concentration in soil at the point of exposure (activity/mass soil)

From equations (1) and (4), (3) and (4), and (3) and (5), the EL may be calculated for noncarcinogenic, carcinogenic, and radiological effects, respectively, using the preselected values for HQ and risk. These resulting equations and the parameters used for calculating the ELs for soil are presented in Tables A-1, A-2, and A-3. The EPA-derived toxicity factors (RfDs and CSFs) used in Tables A-1 through A-3 are presented in Table A-4.

The combined soil and dust ingestion rates used in Tables A-1 through A-3 are presented in OSWER Directive 9285.6-03 (EPA 1991b), which specifies 200 mg per day for children ages 1 through 6 (6 years of exposure) and 100 mg per day for others. Presently there is no widely accepted method for determining the relative contribution of each medium (i.e., soil vs. dust) to these daily totals, and the effect of climatic variations (e.g., snow cover) on these values has yet to be determined. Thus, for this preliminary evaluation, a constant, year round exposure is assumed (i.e., 350 days/year).

The equation for calculating a 30-year residential exposure to soil/dust is divided into two parts. First, a 6-year exposure duration is evaluated for young children which accounts for the period of highest soil ingestion (200 mg/day) and lowest body weight (15 kg). Second, a 24-year exposure duration is assessed for older children and adults by using a lower soil ingestion rate (100 mg/day) and an adult body weight (70 kg) (EPA 1991b).

The calculated ELs and corresponding detection limits for each analyte with an EPA-derived toxicity factor are presented in Table A-5. Comparison of these values indicates that, in general,

the ELs are greater than their corresponding detection limit. Arsenic, beryllium, benzo(a)pyrene, and Aroclor 1254 were found to have ELs below the analytical detection limits. However, in all four cases, the estimated ELs were within a factor of 10 of the GRRASP-specified detection limits. These ELs were estimated using a target risk level of $1x10^{-6}$. Using the GRRASP-specified detection limits in place of the estimated ELs would result in a risk level of $5.5x10^{-6}$ for arsenic, $6.7x10^{-6}$ for beryllium, $3.0x10^{-6}$ for benzo(a)pyrene, and $1.9x10^{-6}$ for Aroclor 1254. In the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 CFR Part 300), EPA states that: "For known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper-bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6}." If GRRASP-specified detection limits are used, concentrations of arsenic, beryllium, benzo(a)pyrene, and Aroclor 1254 near the detection limits will result in estimated risk levels that are acceptable. Therefore, no special analytical procedures will be used.

TABLE A-1
EXPOSURE LIMIT CALCULATIONS
FOR NONCARCINOGENIC CHEMICALS IN SOIL

$$EL = \frac{RfD \times HQ \times BW \times AT}{IR \times CF \times ED \times EF \times FI \times ME}$$

EL = exposure limit for soil (mg/kg)

RfD = oral reference dose (mg/kg-day)

HQ = hazard quotient (unitless)
     =   1.0

BW = body weight (kg)
     = resident[a] - 70 kg adult and 15 kg child

AT = averaging time (period over which exposure is averaged)
     = ED x 365 days/year

IR = ingestion rate (mg/day)
     = resident[a] - 100 mg/kg adult and 200 mg/day child

CF = conversion factor (1E-6 kg/mg)

ED = exposure duration (years)
     = resident[a] - 24 years adult and 6 years child

EF = exposure frequency (days/year)
     = residential - 350 days/year

FI = Fraction ingested[b]
      resident - 1.0

ME = Matrix effect
     = 1.0

---

[a]   Residential exposure has been time-weighted averaged to consider both child and adult exposure during the 30-year exposure duration per OSWER Directive 9850.4 (EPA 1989). Calculations were conducted in accordance EPA guidance contained in Risk Assessment Guidance for Superfund; Volume 1 - Human Health Evaluation Manual (Part B), EPA, 1991

[b]   The residential FI assumes that residents are in contact with chemical containing media 100 percent of their time at home.

TABLE A-2

EXPOSURE LIMIT CALCULATIONS
FOR CARCINOGENIC CHEMICALS IN SOIL

$$EL = \frac{RISK \times BW \times AT}{IR \times CF \times ED \times EF \times CSF \times RP \times FI \times ME}$$

EL   =   exposure limit for soil (mg/kg)

RISK =   1E - 6

BW   =   body weight (kg)
       =   resident[a] - 70 kg adult and 15 kg child

AT   =   averaging time (days) (period over which exposure is averaged)
     =   70 years x 365 days/year

IR   =   ingestion rate (mg/day)
    =   resident[a] - 100 mg/day adult and 200 mg/day child

CF   =   conversion factor (1E-6 kg/mg)

ED   =   exposure duration (years)
     =   resident[a] - 24 years adult and 6 years child

EF   =   exposure frequency (days/year)
    =   residential[a] - 350 days/year

CSF   =   carcinogenic slope factor $(mg/kg-day)^{-1}$

RP   =   relative potency (factor considered only for PAHs)[b]

FI   =   Fraction ingested from contaminated source[c]
       residential - 1.0

ME   =   Matrix effect
     =   1.0

---

[a]   Residential exposure has been time-weighted averaged to consider both child and adult exposures during the 30-year exposure duration per OSWER Directive 9850.4 (EPA 1989). Calculations were conducted in accordance with EPA guidance contained in Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part B), (EPA, 1991).

TABLE A-2
(Concluded)

b   The relative potency factors used are interim guidance values from EPA Region IV, February 11, 1992.

c   The FI assumes that residents are in contact with chemical-containing media 100 percent of their time at home.

TABLE A-3
EXPOSURE LIMIT CALCULATIONS
FOR RADIONUCLIDES IN SOIL

$$EL = \frac{RISK}{CSF \times IR \times ED \times EF \times CF \times FI \times ME}$$

EL = exposure limit for soil (pCi/g)

RISK = 1E - 6

CSF = carcinogenic slope factor $(pCi)^{-1}$

IR = ingestion rate (g/day)
= residential - 100 mg/day adult and 200 mg/day child

ED = exposure duration (years)
= resident[a] - 24 years adult and 6 years child

EF = exposure frequency (day/year)
= resident - 350 days/year

CF = conversion factor $(10^{-3}$ g/mg)

FI = Fraction ingested from contaminated source[b]
residential - 1.0

ME = Matrix effect[e]
= 1.0

[a] Residential exposure has been time-weighted to consider both child and adult exposures during the 30 year exposure duration per OSWER Directive 9850.4 (EPA 1989). Calculations were conducted in accordance with EPA guidance contained in Risk Assessment Guidance for Superfund; Volume 1 - Human Health Evaluation Manual (Part B) (EPA, 1991).

$$pCi/g = \frac{1}{(pCi)^{-1} * mg/d * y * d/y * g/mg}$$

[b] The FI assumes that residents are in contact with chemical-containing media 100 percent of their time at home.

TABLE A-4

TOXICITY VALUES USED TO COMPUTE EXPOSURE LIMITS

Substance	Chronic Oral RfD (pCi/g)	Oral Carcinogenic Slope Factor (pCi/g)	Relative Potency
Radionuclides			
Sr^{89}	NA	3.0E-12	NA
Cs^{137}	NA	2.8E-11	NA
Ra^{226}	NA	1.2E-10	NA
Ra^{228}	NA	1.0E-10	NA

Substance	Chronic Oral RfD (mg/kg-day)	Oral Carcinogenic Slope Factor $(mg/kg-day)^{-1}$	Relative Potency
Metals			
Antimony	4E-4	NA	NA
Arsenic	3E-4	1.75	NA
Barium	7E-2	NA	NA
Beryllium	5E-3	4.3	NA
Cadmium	1E-3	NA	NA
Chromium	5E-3	NA	NA
Chromium VI	5E-3	NA	NA
Manganese	1E-1	NA	NA
Mercury	3E-4	NA	NA
Molybdenum	5E-3	NA	NA
Nickel	2E-2	NA	NA
Selenium	5E-3	NA	NA
Silver	3E-3	NA	NA
Strontium	8.8E-1	NA	NA
Thallium	7E-5	NA	NA
Tin	6E-1	NA	NA
Vanadium	7E-3	NA	NA
Zinc	2E-1	NA	NA
Semi-volatiles			
Diethylphthalate	8E-1	NA	NA
Acenaphthene	6E-2	NA	NA

TABLE A-4
(Concluded)

Substance	Chronic Oral RfD (mg/kg-day)	Oral Carcinogenic Slope Factor (mg/kg-day)$^{-1}$	Relative Potency
Fluorene	4E-2	NA	NA
N-Nitrosodiphenylamine	NA	4.9E-3	NA
Anthracene	3E-1	5.8[a]	0.1
Pyrene	3E-2	NA	NA
Benzo(a)anthracene	NA	5.8[a]	0.1[b]
bis(2-ethylhexyl)Phthalate	2E-2	1.4E-2	NA
Chrysene	NA	5.8[a]	0.01[b]
Benzo(b)fluoranthene	NA	5.8[a]	0.1[b]
Benzo(k)fluoranthene	NA	5.8[a]	0.1[b]
Benzo(a)pyrene	NA	5.8[a]	1.0[b]
Indeno(1,2,3-cd)pyrene	NA	5.8[a]	0.1[b]
Benzo(g,h,i)perylene	NA	5.8[a]	0.01
Pesticides/PCBs			
Aroclor	NA	7.7	NA
Beta-BHC	NA	1.8	NA

NA   Not available

[a]   The carcinogenic slope factor value for benzo(a)pyrene has been used for all EPA Group B2 polycyclic aromatic hydrocarbons (PAHs).

[b]   The relative potency factors used are interim guidance values from EPA Region IV, February 11, 1992.

TABLE A-5

EXPOSURE LIMITS IN SOIL
ON-SITE RESIDENT

Substance	EL Noncarcinogenic (pCi/g)	EL Carcinogenic (pCi/g)	Detection Limit[a] (pCi/g)
Radionuclides			
$Sr^{89,90}$	NA	256	1.0
Cs^{137}	NA	27	0.1
Ra^{226}	NA	6.4	0.5
Ra^{228}	NA	7.7	0.5

Substance	EL Noncarcinogenic (mg/kg)	EL Carcinogenic (mg/kg)	Detection Limit[a] (mg/kg)
Metals			
Antimony	110	NA	12
Arsenic	81	0.37	2
Barium	18,900	NA	40
Beryllium	1,350	0.15	1.0
Cadmium	270	NA	1
Chromium	1,350	NA	2
Manganese	27,000	NA	3
Mercury	81	NA	0.2
Molybdenum	1,350	NA	40
Nickel	5,400	NA	8
Selenium	1,350	NA	1
Silver	810	NA	2
Strontium	238,000	NA	40
Thallium	19	NA	2
Tin	162,000	NA	40
Vanadium	1,900	NA	10
Zinc	54,000	NA	4

TABLE A-5
(Concluded)

Substance	EL Noncarcinogenic (mg/kg)	EL Carcinogenic (mg/kg)	Detection Limit[a] (mg/kg)
Semi-volatiles			
Diethylphthalate	216,000	NA	.33
Acenaphthene	16,200	NA	.33
Fluorene	11,000	NA	.33
N-Nitrosodiphenylamine	NA	130	.33
Anthracene	81,000	1.1	.33
Pyrene	8,100	NA	.33
Benzo(a)anthracene	NA	1.1	.33
bis(2-ethylhexyl)Phthalate	5,400	46	.33
Chrysene	NA	11	.33
Benzo(b)fluoranthene	NA	1.1	.33
Benzo(k)fluoranthene	NA	1.1	.33
Benzo(a)pyrene	NA	0.11	.33
Indeno(1,2,3-cd)pyrene	NA	1.1	.33
Benzo(g,h,i)perylene	NA	11	.33
Pesticides/PCBs			
Aroclor 1254	NA	0.083	0.160
Beta-BHC	NA	0.36	0.008

NA   Not available
mg/kg milligram/kilogram
pCi/g picoCurie/gram
[a]   See General Radiochemistry and Routine Analytical Services Protocol (GRRASP) (EG&G 1990b)

EXPLANATION

INDIVIDUAL HAZARDOUS SUBSTANCE
SITE AND IHSS DESIGNATION

LOCATION OF BARRELS DETERMINED BY
VISUAL INSPECTION OR MAGNETOMETER
SURVEY

SOURCE AREAS
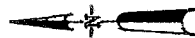
Scale: 1" = 600'

0'   300'   600'

CONTOUR INTERVAL = 20'

U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT NO. 2
PHASE RFI/RI SURFICIAL SOIL SAMPLING
TECHNICAL MEMORANDUM

OU-2 BOUNDARY, REMEDIAL
INVESTIGATION AREAS, AND
INDIVIDUAL HAZARDOUS
SUBSTANCE SITES (IHSS's)

FIGURE 1-1

January 1993

POND B-5

POND B-4

POND B-3

POND B-2

POND B-1

EAST TRENCHES AREA

MOUND AREA

903 PAD AREA

POND C-1

POND C-2
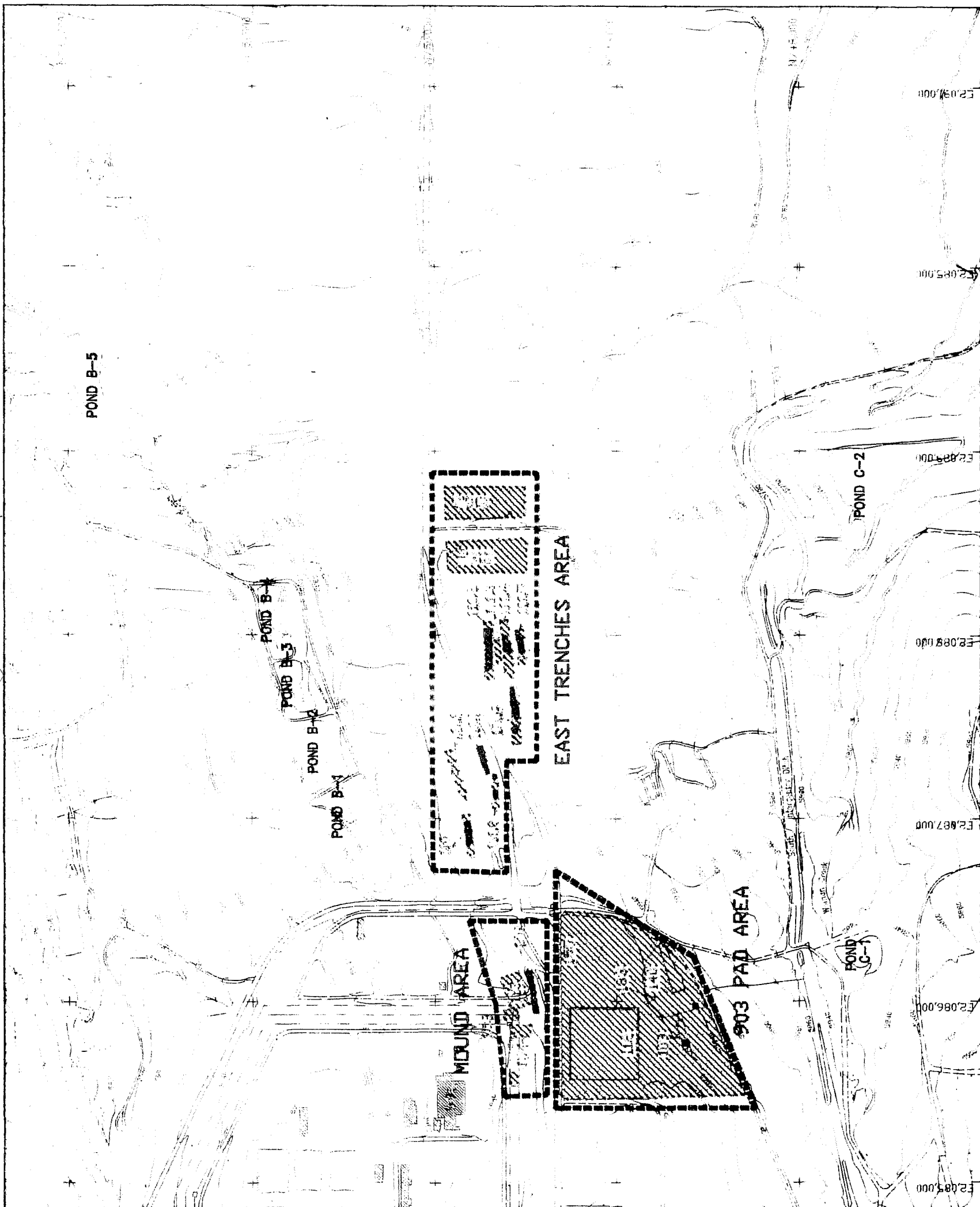
EXPLANATION

- HISTORICAL BEDROCK MONITORING WELL
- HISTORICAL ALLUVIAL MONITORING WELL
- PRE-1986 MONITORING WELL
- HISTORICAL BOREHOLE
- INDIVIDUAL HAZARDOUS SUBSTANCE SITE LOCATION
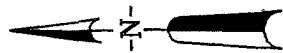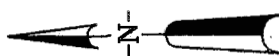
SCALE : 1 INCH = 1000 FEET

1000'   0   1000'

CONTOUR INTERVAL = 20'

-N-

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SURFACE SOIL SAMPLING TECHNICAL MEMORANDUM

HISTORICAL MONITORING WELL
AND BOREHOLE LOCATIONS
FIGURE 1-2A

JANUARY 1993
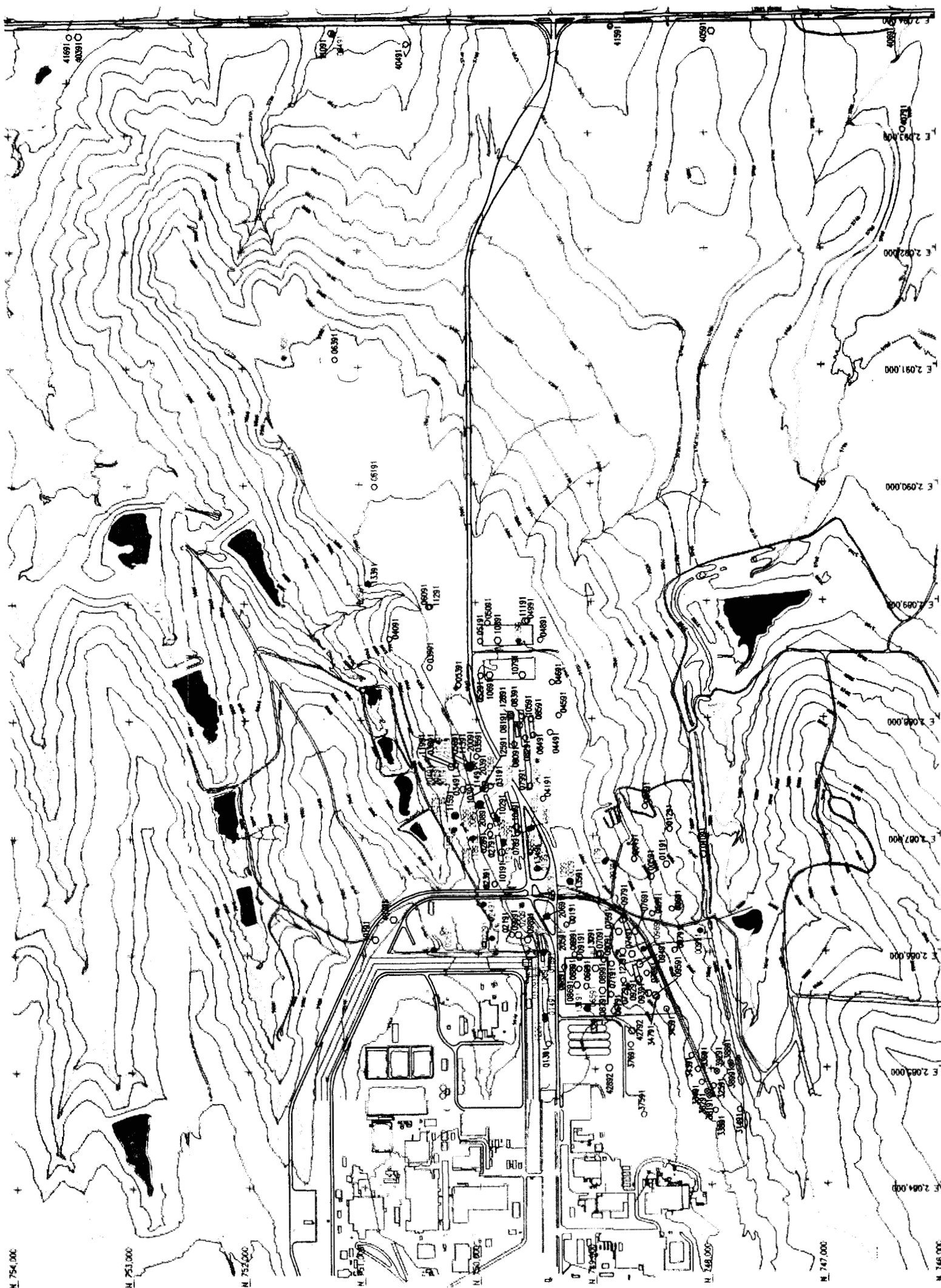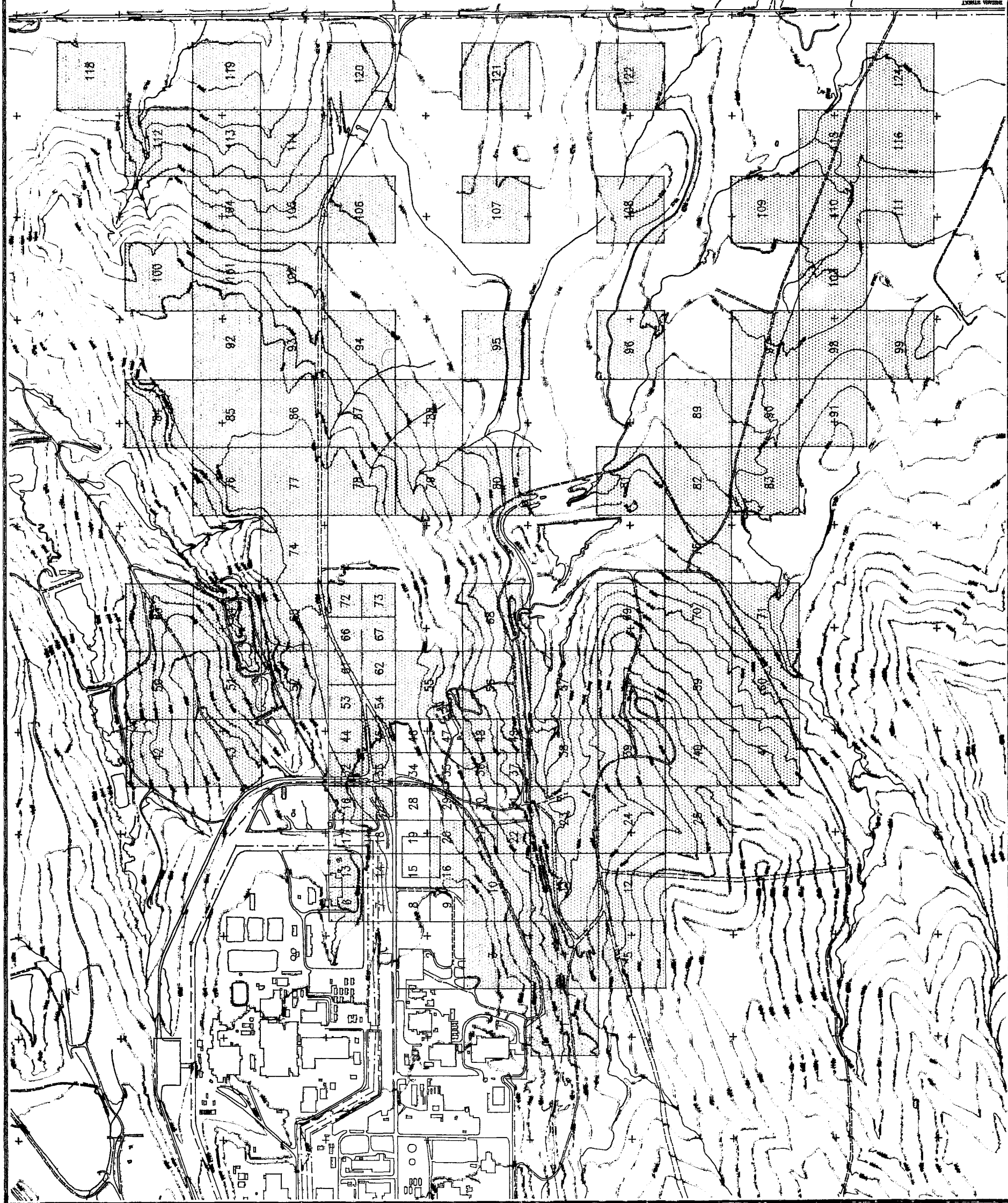
EXPLANATION

10 ACRE SAMPLING PLOT LOCATIONS

2.5 ACRE SAMPLING PLOT LOCATIONS

Pu239,240, Am 241, U 233,234,235,
236,238,239

25.

25

25

1" = 1000'

0'   500'   1000'

CONTOUR INTERVAL = 40'

-N-

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OPERABLE UNIT NO. 2
SURFICIAL SOIL SAMPLING
TECHNICAL MEMORANDUM

CURRENT PHASE II SURFICIAL SOIL
SAMPLING PLOT LOCATIONS AND ANALYSES

FIGURE 1-3

January 1993

INDIANA STREET

R33M025A-PJCW-080692/1000

PRIMARY SOURCE | PRIMARY RELEASE MECHANISM | SECONDARY SOURCE | SECONDARY RELEASE MECHANISM | TERTIARY SOURCE | TERTIARY RELEASE MECHANISM | QUATERNARY SOURCE

Chemical Fate and Transport Flow Diagram

Contaminated Soil → Storm Water Runoff → Surface Water / Sediments → Fish Uptake / Animal Uptake → Fish / Livestock/Animals

Contaminated Soil → Volatilization → Indoor Air (VOCs) / Outdoor Air (VOCs)

Contaminated Soil → Wind Suspension → Outdoor Air (Particulates) → Soil Deposition / Plant Deposition → Soil / Vegetables/Plants → Radioactive Decay

Contaminated Soil → Infiltration and Percolation → Alluvial Groundwater → Volatilization / Surface Discharge → Indoor Air (VOCs) / Outdoor Air (VOCs) / Surface Water → Fish Uptake / Animal Uptake → Fish / Livestock/Animals

Contaminated Soil → Direct Contact

Contaminated Soil → Radioactive Decay

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OPERABLE UNIT 2
PHASE II RFI/RI EXPOSURE ASSESSMENT
TECHNICAL MEMORANDUM

CHEMICAL FATE AND
TRANSPORT FLOW DIAGRAM

FIG. NO. 1-4   January 1993

FCONB

LEGEND

△ APPROXIMATE EXPOSURE POINT
FUTURE OFF-SITE RESIDENTS.

▲ EXPOSURE POINT
CURRENT RESIDENT

▨ EXPOSURE AREA FUTURE ECOLOGICAL
RESEARCH, FUTURE WORKERS,
FUTURE ON-SITE RESIDENTS.

SCALE IN FEET

0   1000   2000   4000
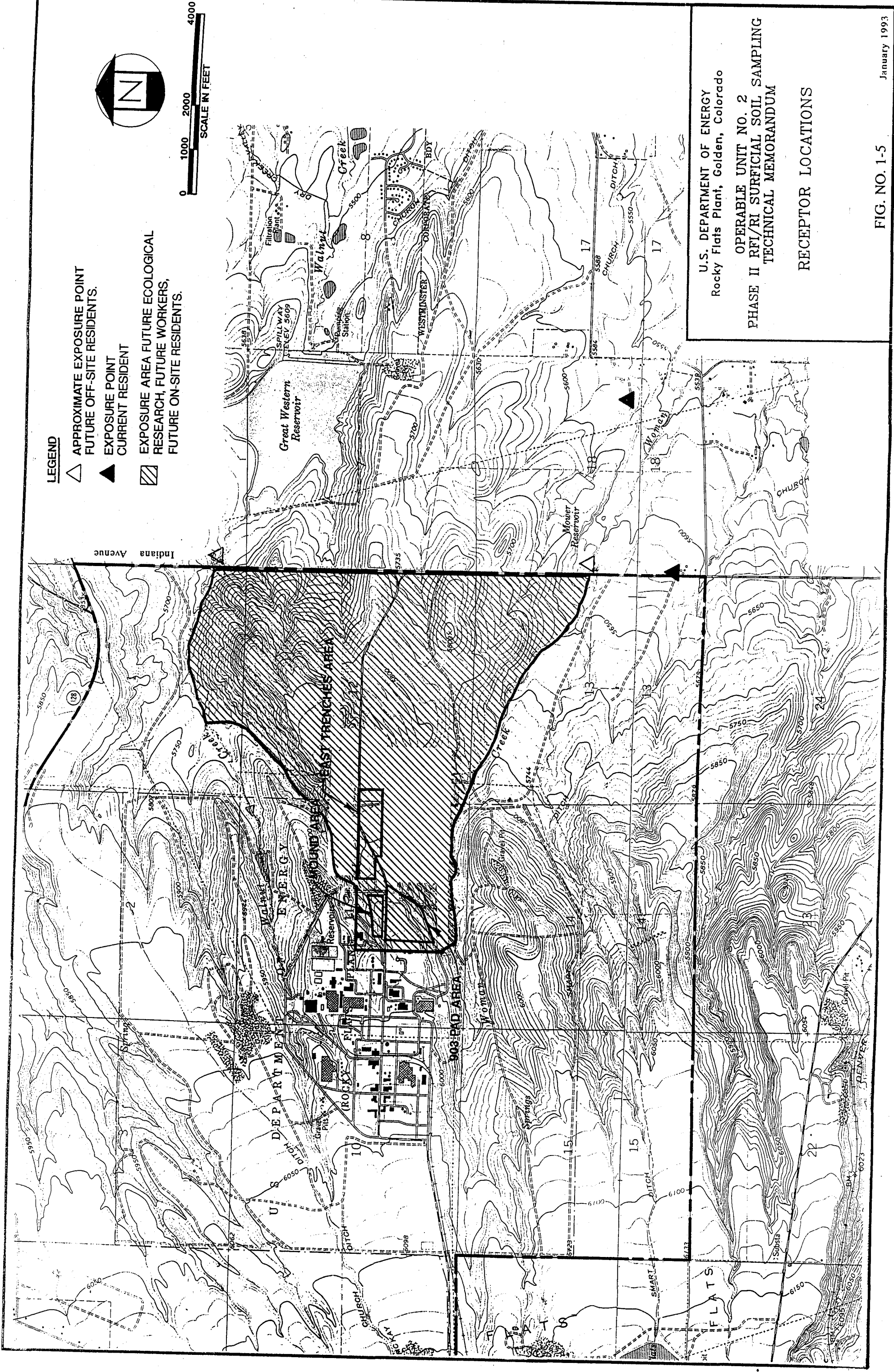
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PHASE II RFI/RI SURFICIAL SOIL SAMPLING
TECHNICAL MEMORANDUM

RECEPTOR LOCATIONS

FIG. NO. 1-5

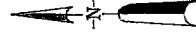January 1993

EXPLANATION

216.2 — INDIVIDUAL HAZARDOUS SUBSTANCE SITE AND IHSS DESIGNATION

— LOCATION OF BARRELS DETERMINED BY VISUAL INSPECTION OR MAGNETOMETER SURVEY

— SOURCE AREAS

— IHSS WITH HISTORICAL INFORMATION SUGGESTING POTENTIAL SURFACE SOIL CONTAMINATION

1810 — 50'x100' SURFACE SOIL SAMPLING PLOT

— BIASED SAMPLE LOCATION

1" = 600'

0'   300'   600'

CONTOUR INTERVAL = 40'

-N-
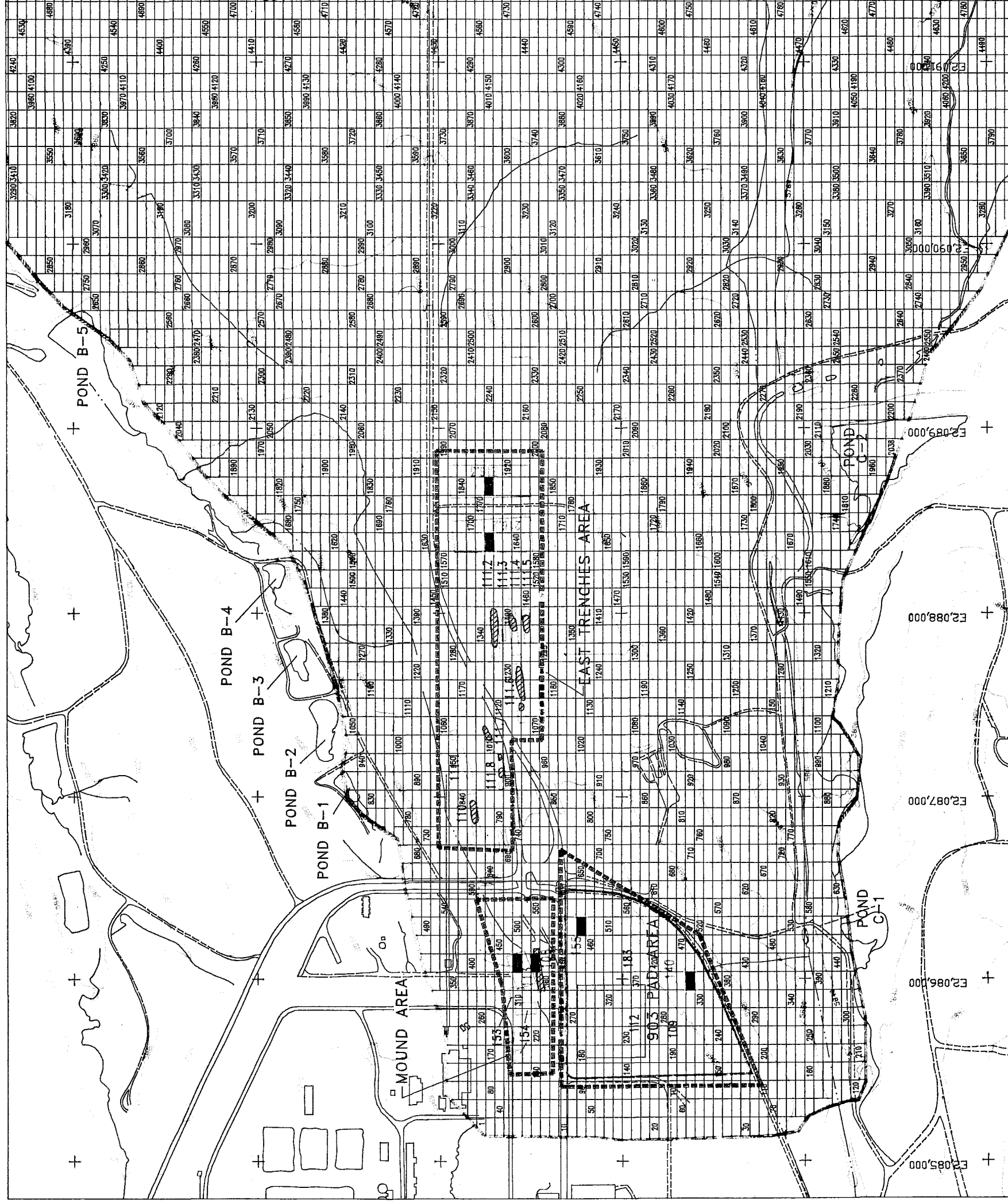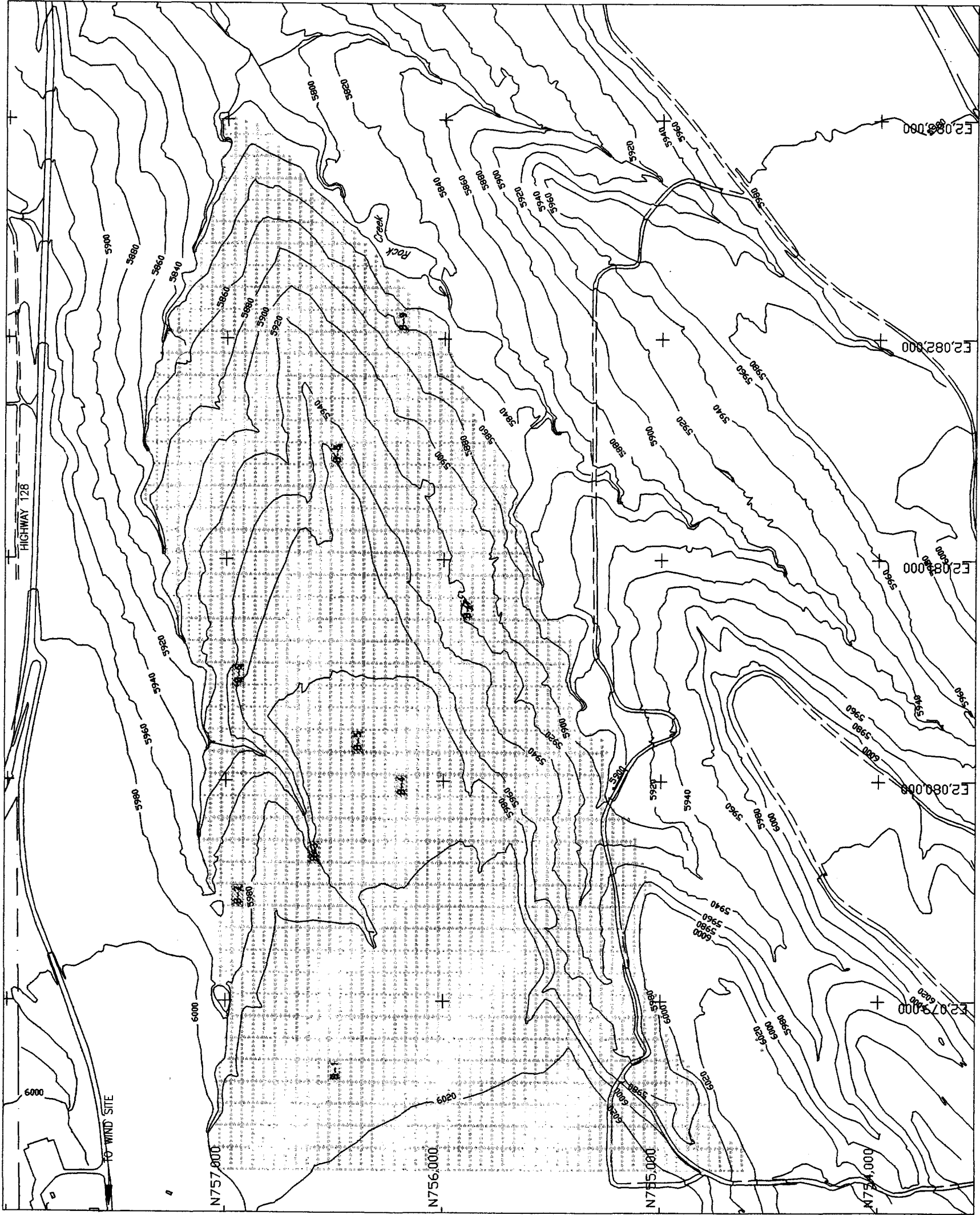
EXPLANATION

PROPOSED SURFICIAL SOIL POLYGON (100' x 50')

BACKGROUND SURFACE SOIL SAMPLING LOCATION
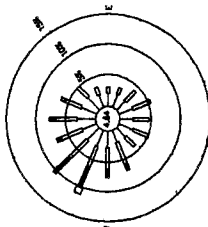
(OU1) BACKGROUND SURFACE SOIL SAMPLING LOCATIONS

KEY

Scale: 1" = 500'

0'   250'   500'
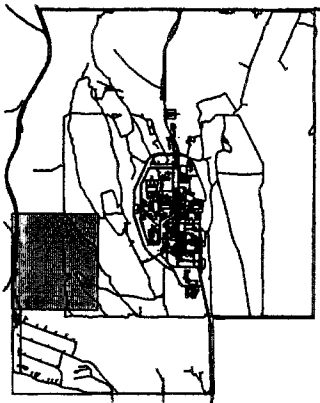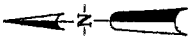
CONTOUR INTERVAL = 20'
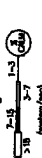
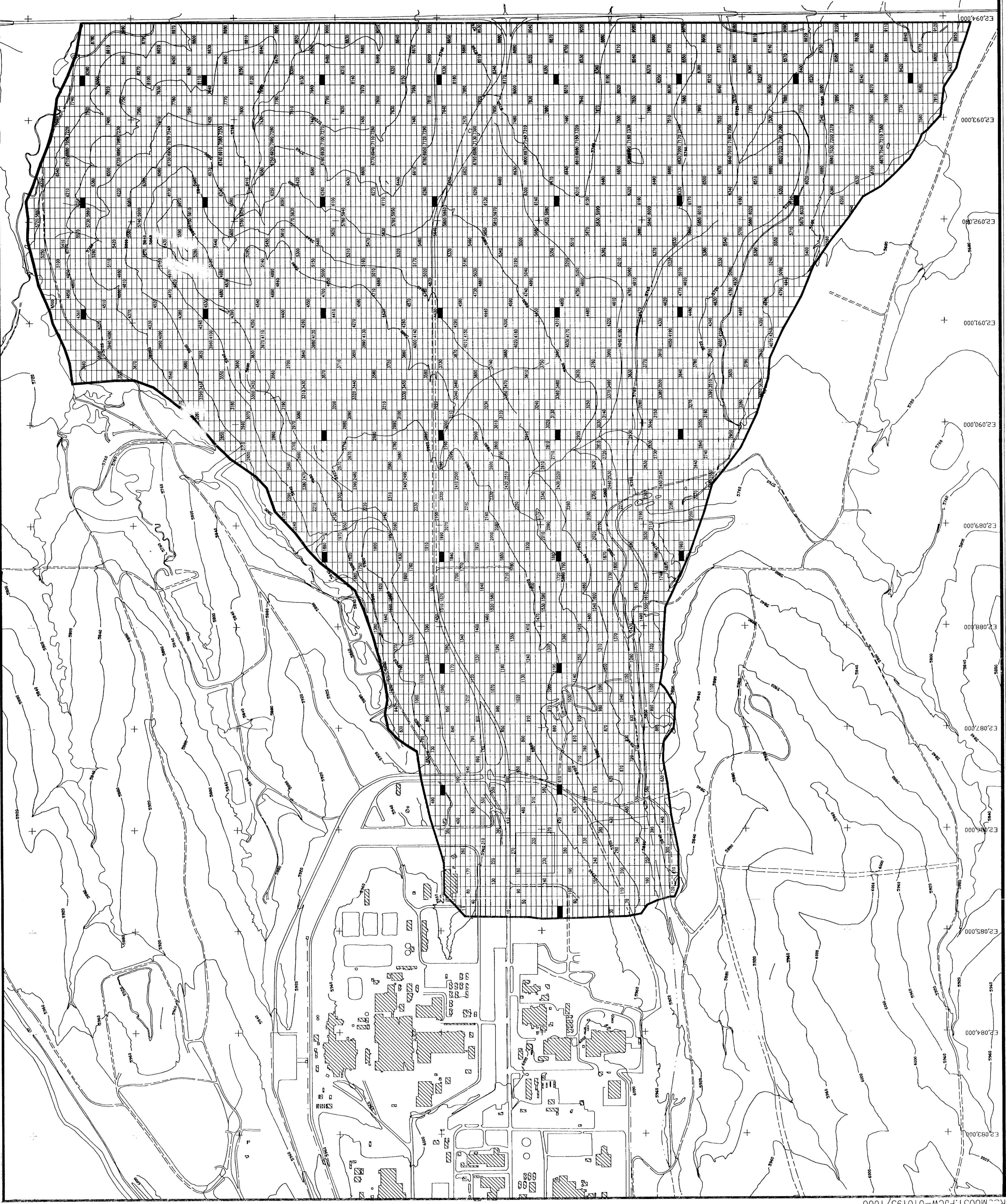RFP 1990 WIND ROSE
SOURCE: EG&G, 1990d

U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT NO. 2
SURFACE SOIL SAMPLING
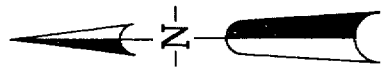TECHNICAL MEMORANDUM

BACKGROUND SURFACE SOIL
SAMPLE AREA

FIGURE 2-6

January, 1993

BCKG-S03

EXPLANATION

OU-2 BOUNDARY

50'x100' PLOTS

PROPOSED BIASED SAMPLING
PLOT LOCATION

PROPOSED GRID-BASED
SAMPLING PLOT LOCATION

1" = 500'

0'   250'   500'

CONTOUR INTERVAL = 40'

-N-

U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT NO. 2
SURFICIAL SOIL SAMPLING
TECHNICAL MEMORANDUM

50'x100' SAMPLING PLOT LOCATIONS
FUTURE ON-SITE RESIDENTIAL USE

FIGURE 2-5

January 1993

RCM0051.PJCW-010193/1000